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OF

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A
MANUAL
OF
ZOOLOGY.

By M. MILNE EDWARDS.

TRANSLATED FROM THE LAST FRENCH EDITION
By R. KNOX, M.D., F.R.S.E.

SECOND EDITION.
WITH MANY ADDITIONAL OBSERVATIONS, AND ILLUSTRATED BY
572 HIGHLY-FINISHED WOOD ENGRAVINGS.

EDITED BY
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NOTICE TO THE FIRST EDITION.

This manual is one of three which, taken together, form the Elementary Course of Natural History prescribed and sanctioned by the Council of Public Instruction of France. The Botanical work was written by the grandson of the celebrated Jussieu; the Mineralogical and Geological portion of the course by M. F. S. Beudant, a gentleman distinguished for his knowledge of these sciences; the Zoological Manual, now for the first time translated, is the production of my most esteemed friend, M. Milne Edwards, one of the first of living zoologists.

The work, in its original form, has already passed through seven editions: a sure proof of its merit. It is admirably adapted, by the simplicity of its style and practical character, to form a safe text-book in all schools and colleges, and to aid in that which I have never lost sight of,—namely, the introduction of my favourite pursuit, Zoology, into universities as a recognised branch of general education.

Thinking it would be but an act of justice, though tardy, to place before the English reader a work of an esteemed friend, which, according to the fashion of the day, has formed the *stock in trade* of so many English, Scotch, Irish, and American literary contrabandists, I wrote M. Edwards on the subject, and received from him the following letter,—a guarantee to the public that the Translation has been undertaken with the Author's full approbation:—

"Vernet les Bains, Pyrénées Orientales,
le 28 Août, 1855.

"Monsieur et cher Confrère,—Il ne peut m'être que très agréable de voir paraitre sous vos auspices une traduction anglaise de mon petit ouvrage élémentaire de Zoologie; aussitôt mon retour à Paris j'aurais le plaisir de vous adresser une exemplaire de la dernière édition. Le nombre des exemplaires déjà vendus s'elèvent en tout à plus de 30,000; ce qui me fait espérer que la traduction anglaise se placerait bien.

"Veuillez agréer, Monsieur et cher Confrère, la nouvelle assurance de ma parfaite considération.

(Signé) "MILNE EDWARDS."

"À M. le Docteur Knox."

As a scientific man, and a teacher of Anatomy and of the great principles of Zoology to thousands, including the names of many of the most celebrated scientific men of the day, I ought not perhaps to notice the literary pirates to whom I have just alluded, were it not that, during the last hundred years they have, in despite of many excellent English writers, greatly retarded the progress of Zoology in Britain and elsewhere, wherever, indeed, the English language is spoken. Carefully excluding from their compilations all elevated and correct views of science, they have, by their anecdotic and quasi-popular style, contributed to debase the works of the most eminent zoologists to such an extent that the grand labours of Buffon, the masterly researches of Cuvier, the profound views of Goethe, Oken, and Spix can scarcely be recognised. Their views are anti-scientific, anti-educational; calculated, if not devised, to retard the progress of the human mind.

The translation being addressed to Englishmen, lovers of matters-of-fact in science as well as in other things, I have done my best to avoid all repetitions, all French idioms, all lengthened treatment of physiological and metaphysical hypotheses; but in doing so I have scrupulously avoided omitting any fact or idea or opinion of the author. The anatomical details of the work I have endeavoured to give in as brief, concise, and simple a manner as befits such matters. Anatomy is a science of facts and of demonstrations; even when the objects are present, as in lectures (and this was the original form of M. Edwards's work), it is a mistake to overload their description with terms, whether technical or popular: my vast experience as a teacher of Anatomy early taught me this. In French the error is less obvious than in English, a language which does not readily accommodate itself to those combinations of unclassical terms which all science unfortunately requires; which sound harshly to the ears of the classical scholar, and have greatly retarded, no doubt, the accomplishment of that object which is the aim of this work,—namely, the introduction, in England, of Zoology as a branch of primary education.

R. K.

NOTICE TO THE SECOND EDITION.

ENCOURAGED by the extraordinary patronage bestowed on the first English edition of this work (the sale of 3500 copies), the translator has spared no pains to render this new edition deserving the patronage already bestowed on the first. He has added many new observations, derived as well from his own researches as from those of others, and has illustrated these by numerous additional wood engravings. He trusts, therefore, that the new edition will be found *au courant* with the present state of zoological knowledge in Europe.

R. K.

LONDON, 1862.

NOTE TO SECOND EDITION.

MY late friend Dr. Knox having completed the revision of the present edition of Milne Edwards's Manual of Zoology, only survived to correct the proofs as far as the thirty-second page. A short period after his lamented decease, Mr. Renshaw confided this editorial duty to me, with the expression of his wish that, out of respect to the memory of the late Dr. Knox, I should make as few alterations as possible. Having enjoyed the privilege of the personal acquaintance of the venerable anatomist until the period of his decease, I also was anxious to leave this posthumous edition of his translation of Milne Edwards's work in the form in which Dr. Knox would have desired it to appear, had he survived, and therefore, with the exception of a few cases, in which an error of fact had been inadvertently passed over, I have left the manuscript untouched.

The present edition differs from the preceding by the introduction of some graphic sketches by one of Dr. Knox's most distinguished pupils, the late Professor Edward Forbes.

Two Tables of Zoological Classification are appended, and a Glossary, which it is thought may prove useful, has been incorporated with an Index, which has been added for the first time, in this edition.

C. C. B.

INTRODUCTION TO THE FIRST EDITION.

THE task I have undertaken, and which I now complete, is simple, and conformable to all my views, studies, and pursuits. Esteem for the author and for a family I have long known, induced me to undertake the translation of an elementary work on Zoology occupying that difficult and doubtful position in which all such works are of necessity placed. Addressed to professional students, and yet not exclusively so, who, partially educated, as the case may be, are about to qualify themselves for embarking in some one or other of the great professions which form the occupation of the intellectual world, such studies seem uncalled for as barren of future profitable results. That such a feeling prevails with most professional students—using the term professional in its widest acceptation—I am well aware; indeed, as regards the students of one of these learned professions, none can know better, if so well, as I do. The Medical Director of the anatomical studies of many thousands of medical students, I have ever found them adverse to science, strictly so called; especially to that branch of zoological science termed Natural History. They desire to be practical. Zoology is not a practical art: in this view, therefore, it leads to nothing.

John Hunter had lived and laboured: his vast ideas, his brilliant discoveries, his views, which seem more like inspirations than the natural result of an industry unsurpassed, lay buried in the hall of a corporate body with whom, as a surgeon, he was accidentally associated: but he had laboured in vain. His views he placed before the world in the form of a museum, to which none of the labours of men's hands can be compared—unless it be, and these no doubt excel, the handiwork of those who carved the Medicean Venus and the Belvidere Apollo. Yet he had laboured in vain, for never, I believe, at any period of its history, was Zoology in a lower condition in Britain than that in which I found it when, returning from France, in the summer of 1825, I submitted to a small but select class an outline of those great views which France and Germany had taught me, and which I have continued to meditate and reflect on to the present day. Since that period the educational institutions of the country have become somewhat multiplied, perhaps improved. The pressure of continental opinion has told on Britain, and ere long it is by no means improbable the sciences of simple observation may be deemed, if not equal in importance to those great branches of human knowledge wrapped up in the study of numbers and of literature, at least useful, practically calculated to expand the intellect—the first object of all education.

It is a matter not only curious in itself, but fraught with interest to the future historian, to trace, however briefly, the gradual unfolding of modern education, as contrasted not merely with the ancient but with that which, even in my younger days, prevailed everywhere. The interest lies chiefly in contrasting the low estimate which prevailed respecting the nature and character of the sciences of simple observation, as compared with true science; that description of knowledge which admits of *à priori* reasoning, from that which scarcely, if at all, admits of such. Hence, no doubt, the exclusion of chemistry, anatomy, natural history, from the curriculum of all universities, schools, colleges, examining bodies. Medicine, an art mistaken for a science, usurped their place, and these branches of knowledge were tacked to medicine furtively, but not mentioned or spoken of aloud. The sciences I speak of were merely permitted to exist under a withered and degraded form; and a faculty which never ought to have had a place in any university, came at last in some to play a prominent part; as if to complete the misapprehensions of true science, it required only to add to these the mechanical art of surgery; and this of course followed: nor could it have been otherwise in a country where *constants* are alone looked on as valuable, applicative, productive; industrial facts bearing on the great questions of profit and loss—direct, immediate, are alone esteemed.

Generally speaking, the continental universities resisted this pollution: they refused all association with faculties, medical or otherwise, and more especially that of France; access to the scientific departments of the army was closed, by the rigorous education and examination of the Polytechnic School, to all who had not mastered the elements at least of natural science; whilst of the aspirant for the diploma of medicine a first university degree was demanded. Now that degree the candidate could not obtain if ignorant of those branches of knowledge which constitute Natural History. The necessity produced a want, namely, a brief manual of instruction suited to such a case; the want was supplied in respect of Zoology by my friend M. Milne Edwards, whose work in an English dress I now present to the public; the botanical manual was the work of a descendant of the illustrious Jussieu; the mineralogical and geological by Beudant: the three comprising all Natural History, properly so called.

But of one thing I am thoroughly convinced. This improved condition of education, even in France, was the result of accident,—of the accidental appearance in France of a man destined to revolutionize all zoological science, viewed under every possible aspect—that man was George Cuvier. To be convinced of the truth of this view, we have but rapidly to trace the history of Zoology from the period of the immortal

Historia Animalium of Aristotle to that of St. Pierre and Faujas St. Fond.*

Before Rome existed, and before the *Iliad* was composed, Egypt had its Pyramids and its Thebes; that land of practical science, bordered on regions of the earth surpassed by none for variety in the forms of animal life. I allude to Africa within the tropics. Nearly every animal susceptible of domestication and useful to man had been appropriated by the Coptic race of Egypt and Nubia; whilst all the *wilde* of nature had in succession been exhibited to the nation in various triumphal processions. But all this was merely practical and transitory. It was the same with Rome, Eastern and Western; no science resulted from it, no zoological science, at least; and the dawn of civilization which re-opened in Europe after the dreadful period of the Dark and Middle Ages, found zoological and natural science precisely where it was left by Pliny—a tissue of puerilities, of vague hypotheses, of silly fancies, upon which no critique had ever been exercised.

Notwithstanding the occasional appearance of able men, it continued in this sad state until the close of the seventeenth century. Neither zoology nor mineralogy nor geology had any real existence.

In 1707, or about that period, two men appeared, simultaneously, destined to rescue Zoology at last from the degraded state to which Pliny and his imitators, abounding most in England, had reduced it. These were Carl Linnè and the Count de Buffon. To these truly great men we owe the first attempt to remove the natural sciences from the control of those into whose hands they had fallen. The genius of Linnè led to classification, that of Buffon to description; the one defined, the other described. But the genius of the latter was of a higher cast: it anticipated the future; and men now read with surprise and learn with astonishment (a surprise and astonishment in which I do not partake) that Buffon was no mere compiler, no mere literary man, no mere writer destined to captivate the world by the beauties of a style unmatched, I believe, in France, but a profound philosopher, who had already anticipated nearly all the great truths of the transcendental in science. But neither Buffon nor Linnè, whatever might have been the profundity of their views, offered any demonstration of these views. This is what the world looks for, and rightly expects; rigid demonstration supported the Newtonian hypothesis, else Newton had written in vain. Palissy, the potter, had said as much as Buffon, but, like him, he had offered no demonstration, and the world looked on them as dreamers—dangerous dreamers, of whom the less notice that was taken the better. In Britain, especially, Buffon's works appeared stripped of all their lofty views, disfigured and degraded; he passed, even in France, merely as the naturalist who had best described the hot-blooded quadrupeds, as certain mammals were called even in my days; the bold conjectures of Palissy and of Buffon seemed about to disappear for ever from the field of science. Even Goethe had failed to resuscitate them under other forms. The geological theories of Hutton and Playfair were met successfully by the plausible hypothesis of Werner, when suddenly a man appeared, destined to place natural science for ever on a basis which, if not so fixed as the *Elements* of Euclid, will at least prove as enduring. That man was George Cuvier, a German, born on French soil; an anatomist. This wonderful man, of a rigidly demonstrative turn of mind, when quite young, but well educated, bethought him of investigating "the unknown" in Zoology by means of anatomical research, the only way in which it could be inquired into. Linnè and Buffon had described and defined the exterior: "I will investigate," he said, "the interior:" they ought to correspond: there must be intimate relations between them; anatomical co-relations. Seemingly, and without being aware of it, he had discovered a new element of research—descriptive anatomy; not the vague comparative anatomy of Perrault or Daubenton, but minute descriptive anatomy, worthy of Hunter and of himself. Yet he was very young, and knew nothing of Hunter and but little of Daubenton. Genius directed his steps, that genius which, when it appears, and happily escapes the crushing influences "of established socialisms," is sure to form a new era. Like most of the great men of his day (products of the French revolution), he had outstripped in his merest youth the age he lived in, and rapidly shot beyond that which was to follow.

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* *See* Great Artists and Great Anatomists. London: Van Voorst.

Cuvier's early pursuits were the rectification, by means of anatomy, of the classifications of Buffon and Linnè; but he quickly, as it were instinctively, passed beyond this comparatively narrow field into one which has no limits. Whilst pursuing his inquiries on the structure of the invertebrate kingdom, he soon saw that the animal forms he dissected differed specifically and generically from those fossil forms which lay around him. Palissy, the potter, had seen the same; Buffon had announced the fact: they were declared to be dreamers. Cuvier offered to mankind the *Ossemens Fossiles* in proof that they were so, and from that moment to the present day few have had the hardihood to deny the proof; none but those who regard the Newtonian demonstation as an idle unprofitable dream.

The importance thus given to zoological studies and pursuits by the application of the anatomical method in Zoology, would have commenced and terminated with Cuvier but for this one circumstance—he had created geology, palæontology; that last and most wonderful science, which seems to have no limits. He had shown that without a knowledge of the extinct zoologies there can be no geology, properly speaking; none at least likely to interest man. Now this extinct Zoology cannot be well understood, if at all, without a knowledge of the living zoology, that being the term and mean of comparison. Thus was Zoology forced at last into the schools, universities, and collegiate institutions.*

* Cuvier had shown anatomy to be the only safe basis for testing zoology, and a comparison of it with the extinct the only guide to palæontology; it

The necessity for this was first seen and admitted in France, from whence it naturally was imported into England, where Cuvier and his supposed views had become fashionable; the single geologist at the Board of Ordnance, MacCulloch, was slowly replaced by a body of scientific men, each teaching a different department of natural science: out of this arose a school of practical geology, and various chairs in a similar direction came to be founded in collegiate educational institutions. The illustrious Sedgwick, to whom geology unquestionably owes its present position in Britain, set an example in Cambridge which cannot be too much praised nor too closely followed.

Thus originated the gradual introduction of zoological science into the curriculum of study for university honours demanded of all, I presume, who mean to follow out a professional vocation in France: England slowly follows. The little work I here present to the public contains the best outline ever yet published of such studies; from me it requires no praise; its intrinsic merits and the numerous editions it has already passed through constitute its best recommendation to the English reader.

R. K.

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may be, and has been, called an empirical method, by which I presume is meant that the method is not strictly scientific. I have all my life been of this opinion, but the method notwithstanding has led to results second only, if second, to the Newtonian discoveries.

ELEMENTARY COURSE

OF

ZOOLOGY.

PRELIMINARY IDEAS.

§ 1. *Object and Utility of Natural History.*—Natural History is that science which treats of the structure of bodies spread over the surface of the globe or forming its mass—the phenomena exhibited by these bodies, the characters by which they may be distinguished from each other, and the part they play in the entire creation. Its range is immense, and its importance is not inferior to its extent. Some, but little acquainted with science, see in natural history merely a collection of anecdotic facts, more calculated to excite the curiosity than to exercise the understanding, or a dry study of technical terms and arbitrary classifications. Such an opinion is based on ignorance: and the utility of the study of natural history cannot fail to be recognised by all who possess even the preliminary ideas of the science. The grand and harmonious view it presents of Nature, whose *beau ideal* is so much superior to that of human invention, tends to elevate the mind to lofty and sound thoughts. The knowledge of ourselves and of surrounding objects is not given merely to satisfy the desire for learning which develops itself always according as the intelligence enlarges; it forms a necessary basis to many other studies, and is eminently calculated to give to the judgment that rectitude in the absence of which the most brilliant qualities lose their value, and in the course of life lead the mind astray. On the other hand, to be convinced of the practical importance of the natural sciences, we have only to look to geology and mineralogy, and the services they have rendered to industry; to botany, and to the myriads of beauteous and useful plants it describes, and to horticulture, of which it is the guide; to recollect the animals to which we owe wool, silk, honey—which lend us that power which man so often requires, or which, far from being useful to us, threaten our harvests with destruction; lastly, to consider the long catalogue of human infirmities, and to reflect on the dangerous character of that medicine which is not based on a scientific knowledge of the human structure. But the utility of these sciences does not stop here; in an educational point of view, their study accustoms the mind to proceed from effect to cause, testing each hypothesis by an appeal to facts. Finally, before all other studies, that of natural history trains the mind to *method,* that part of logic without which all investigation is laborious, every exposition obscure.

In claiming for natural history a place in every liberal system of education, we do not mean that all young men should become naturalists. So vast a study and the time required for other studies forbid such an idea; nor would the acquisition of the details on which natural history is based be of any service to the young mind: all that is necessary is that sound, correct notions be placed before the student, and acquired by him, respecting the great questions to solve which is the object of natural history studies; on the constitution of the globe, for example, and the physical revolutions which succeed each other on its surface; on the nature of plants and animals; on the mode in which their functions are exercised; and on the principal modifications of their structure, according to the kind of life for which they are destined. This description of knowledge once acquired is seldom forgotten; it forms a basis for the special studies of those who desire to become naturalists; and is sufficient for those whose pursuits do not lead to science. The University (*of France*) in its programme sanctions this course of study, and enforces it; in this work we propose adopting it.

§ 2. *Division of Natural Bodies into Three Kingdoms.*—All natural bodies, whether spread over the surface of the globe or collected in the interior of the earth, are of two kinds—*mineral* or *unorganized, living* or *organized.* These last are subdivided into two groups—*vegetables* and *animals.* Hence has arisen the expression of the three great kingdoms of nature—the *mineral, vegetable,* and *animal.* In commencing the study of these three kingdoms, it is necessary to inquire, in the first place, on what basis these divisions rest, and to inquire into the fundamental differences which distinguish a mineral from a living body, a plant from an animal.

§ 3. *Differences between Mineral or Inorganic Substances and Living Beings.*—These differences are numerous and striking; they may be thus summed up. They differ in their origin, mode of existence, duration, manner of decay or destruction, general form, intimate structure, and elementary composition.

§ 4. Thus, as to the *mode of origin.*—When a mineral body is formed, it springs immediately from the union of two or more substances, which, by their nature, differ essentially from it, and which combine by reason of the chemical affinities they possess. A living being, on the contrary, is never thus spontaneously formed; it springs from one resembling itself, and the vitality essential to its formation is transmitted in succession from an uninterrupted series of individuals resembling each other. Two substances, in no way resembling each other, chlorine and sodium, for example, by their union form common salt, independent of the presence of this third substance: not so the plant or animal; for its formation a *parent* is necessary, that is, a being resembling it and preceding it in point of time. Such beings, then, require for their formation a foreign impulse, and this they can only receive from a parent.

§ 5. As respects their *mode of existence.*—The two classes of bodies are equally distinct. Rocks and minerals remain internally in a state of rest or repose; if they gain any additional substance, it is by the accretion of matter similar to them; what they lose is accidental, and affects them not. Living bodies, on the contrary, are constantly in a state of composition and decomposition, the consequence of internal movements in their structure. All is in motion. Unceasingly they incorporate foreign substances or molecules with their own, and give out to the external world particles of their own. This vortex, or whirlpool as it were, constitutes what is called *nutrition*, and is essential to life. They grow by *intussusception* and not by *juxtaposition*, like minerals; for the molecules by which they increase penetrate into the interior of organized beings, and are there deposited.

§ 6. At length, having existed for a certain period, the extreme limit of which is definite for each species, the living body infallibly perishes; mineral or unorganized bodies, on the contrary, once formed, exist until destroyed by an external force; their duration is not limited; they are not necessarily destructible: but—I repeat—all that lives is sure to perish; and thus, were it not for the faculty of *reproduction*, not bestowed on minerals, life under every form would soon disappear from the earth.

§ 7. As regards form and size, or volume, we find that living bodies are destined to acquire a certain size and form, gradually and by development, which they did not possess at birth. The form has no geometrical simplicity; with minerals it is quite otherwise. The smallest fragment of marble is as much marble as the largest mass which can be imagined; but a plant or animal can only live by attaining a certain dimension, beyond which it cannot grow. Neither can they be divided into fragments, like minerals, and yet exist as *individuals;* a term which is chiefly applied only to organized beings. When mutilated beyond a certain point, they cease to exist.

§ 8. The intimate structure of living bodies furnishes other characters. They are always composed of fluids and solids, the former being enclosed in cells formed by plates, laminæ, or filaments. It is this structure to which the name of *organization* has been given. Nothing of the kind is to be seen in the mineral kingdom. A spongy and areolar texture, into which liquids may readily penetrate, is, then, a necessary condition for the existence of life, whether animal or vegetable; and hence the name of *organized beings*, as opposed to minerals, which receive the name of *inorganic bodies*.

§ 9. Lastly, the distinction between the two great divisions of natural bodies, the organic and inorganic, extends even to their elementary or chemical composition.

A mineral body may be formed of molecules strictly of one kind, as sulphur or iron; or may result from the union of two or more chemical elements, the number of which exceeds fifty.

With living beings it is different: their chemical composition is always most complex, and in order to render this clear, the constituent elements of such beings have been arranged under three heads or classes. 1. Those which, like water and various salts, present nothing peculiar, and belong to the inorganic bodies. 2. Organic matters, such as sugar, and urea, which are formed under the influence of life. 3. The plastic and viable products, as albumen, fibrin, cellulose, which possess chemical characters of high importance. Into the composition of these there always enter three—sometimes four

—elements, namely, carbon, hydrogen, oxygen, and azote or nitrogen. Such bodies decompose rapidly by becoming putrid when exposed for a certain period to moisture and warmth. They differ also from the others in respect of their molecular constitution, inasmuch as each atom of an organic matter results from the union of many atoms of organized matter, whilst an atom of a mineral body results from the union of but a few. An atom of carbonic acid, for example, is formed of 1 atom of carbon united to 2 atoms of oxygen; whilst 1 atom of *stearine* (a kind of fat) seems to contain 140 atoms of carbon, 134 atoms of hydrogen, and 5 atoms of oxygen.

Now these organized materials form the basis of all the living parts of animals and plants, whilst the inorganic or mineral play only a secondary part in the economy of these beings. Chemically, then, these four elements characterize all living bodies, nothing similar occurring in the mineral kingdom.

§ 10. Thus living bodies differ from the inorganic by their chemical composition, internal structure, general conformation, mode of origin, mode of existence, and manner of destruction. But to characterize them briefly, it is sufficient to say that they are beings which are *nourished* and *reproduced*, these being the most remarkable of vital phenomena. It is the presence of *life*, then, which especially characterizes plants and animals, of which the simplest expression is to *be nourished.*

§ 11. Respecting the nature of *life*, science has no data: but as in physics the cause of heat is, as it were, personified under the name of caloric, so in physiology a special force is admitted as the cause of phenomena wholly inexplicable by the ordinary laws of physics; this is called the *vital force.* Even its laws are beyond calculation, and we can only trace some of the circumstances which seem essential to its manifestation. Thus, by desiccation, life is suspended in certain animals and plants, and reappears when the requisite moisture has been supplied. Another condition of life is, a certain temperature and the influence of the air.

[Of late years the class of experimental physiologists have made many efforts to reduce the whole phenomena of life to the ordinary physical laws of matter, but as yet unsuccessfully.—R. K.]

§ 12. *Organs.*—Life manifests itself through the medium or by means of organs or instruments, more or less numerous, constituting the body of the animal or plant. Between the organs and the functions they perform there is a necessary co-relation; the muscles, for example, are the immediate instruments or organs of motion: while the organs of sense inform us of what surrounds us.

§ 13. *Relations under which Living Beings are Studied.*—The study of the mode of conformation of the organs of an animal or plant is called *anatomy;* the study of their functions, *physiology*. *Anatomy* is the science of structure; *physiology* the science of life. These sciences are mutually dependent, and cannot be studied apart with advantage. A knowledge of mere structure is unimportant, unless combined with a knowledge of function.

Anatomy and physiology constitute the basis of the natural history of organized beings; but these must also be studied under other relations. Hence the study of external characters, in order to distinguish animals and plants readily and with certainty from each other. Classification also, to aid the memory, becomes requisite. The distribution also of animals and plants over the globe is a matter of interest, practically and scientifically; while the laws regulating the distribution merit careful study. The same remark applies to the uses man makes of natural objects. Finally, natural history is not occupied solely with what now exists upon the globe; but by the examination of fossil remains endeavours to discover the history of those ancient inhabitants of the earth, of which so many existed before man himself.

These varied studies naturally divide themselves into two branches: the study of plants is called botany; zoology means the history of the animal kingdom.

GENERAL CHARACTERS OF ANIMALS.

§ 14. *Differences between Animals and Plants.*—In the immense majority of cases, nothing is easier than to distinguish an animal from a plant; yet occasionally this is difficult, in consequence of the great simplicity of structure in some animals. This uncertainty, after all, may belong rather to the imperfection of our knowledge than to the nature of things; and thus it may be said generally, without dwelling more on this subject, that animals differ from plants by characters of high importance, drawn from the nature of the phenomena connected with their mode of life, from their structural arrangements, and from the chemical composition of the principal constituent matters of their bodies.

§ 15. Vegetable life seems mainly occupied with the nutrition of the individual, and the reproduction of others resembling it. Vegetables are *inanimate*, animals—*animated* beings. Animals perceive, reflect, act spontaneously or by their own will; nothing of the kind, properly speaking, exists in plants. Thus vegetables neither feel nor move; animals feel and move. Differences also exist in the manner in which the same functions are carried on in the two classes of beings; these remain with more propriety to be considered afterwards.

§ 16. The faculties of animals being more complex than those of plants, necessitate a greater complexity of organs. These organs differ also in their intimate structure; the tissues in the vegetable affect a *cellular* or utriculose character, cells provided with proper walls and cavities; in animals, the tissues are composed of little plates or laminæ, which intersect each other in such a way as to circumscribe imperfect lacunæ, and thus to constitute masses or membranes, more or less spongy, but not divided into a number of utricules or cells, independent of each other, as in vegetables. Often, it is true, the animal tissue whilst being developed is seen to be composed of little bags (*utricules*); but this structure, which is permanent in plants, is generally but transitory in animals, and is persistent only in a small number of organs, as, for example, in the glands and epidermic membranes.

§ 17. Finally, the organized matters which form the basis of plants are composed of carbon, hydrogen, and oxygen only. To these in animals nitrogen is added. Allowing, however, that there exists in plants azotized matters, and in animals compounds which are not azotized; still the organized matters essential to the constitution of the living organs offer in the two kingdoms the chemical composition we have just indicated.

OF THE ORGANIC TISSUES OF ANIMALS, AND OF THEIR ORGANS.

§ 18. Different elementary substances, but chiefly carbon, hydrogen, oxygen, nitrogen, combine to produce the materials of which animal bodies are composed. Amongst these materials or matters, some are called organized or plastic, and form the essential basis of all the solid parts animated by the vital movement. These plastic materials are less varied than might be at first supposed; for in all animals the basis (*trame*) of the living parts appears to be composed of a substance called *albumen*, or of *fibrin*—which probably is but albumen slightly modified. The solids also resemble each other in having water as a constituent part, to the presence of which they, no doubt, owe their flexibility, softness, and other physical properties essential for the due performance of their functions. But the mode of texture of the solids thus constituted varies much, and the name of *organic tissues* has been given to those parts which in their turn reunite to form the organs.

§ 19. The principal organic tissues of animals are four: the muscular, nervous, cellular, and utricular.

The *muscular tissue* forms what is commonly called the *flesh*; it is the producing agent of all motion, and is composed of fibres, susceptible of contracting or of being shortened. These fibres, wherever placed, may always be distinguished by their contractile faculty, and are always found where motion is performed.

The *nervous tissue* is soft, and generally whitish; it forms the brain and nerves; it is the seat of sensation.

The *connective* or *cellular tissue*, also named areolar or spongy, is, of all the constituent materials of the body, the most abundant. In some of the more simple animals it seems to form the whole body; in those more highly organized it connects and yet insulates all the organs, entering largely into their composition, and being modified in a variety of ways, it forms membranes and a number of other tissues; in its substance the fat is always deposited. It is a whitish substance, elastic, semi-transparent, composed of filaments variously interlaced, and of small lamellæ, more or less consistent, and irregularly united, so as to leave between them cells or lacunæ of variable size. But the walls of these cells are incomplete, and thus permit fluids (or air) to pass freely from one to another; these cells are moistened with a watery and slightly albuminous liquid, called *serosity*.

The *utricular tissue* is composed of little cells or bladders, with distinct walls, glued to each other, either directly or by means of an amorphous organic matter; sometimes these vesicles are rounded, and filled with some particular substance, as fat, for example; at other times they are found flattened and dried up, so as to form lamellæ, as may be seen on the surface of the skin.

Anatomists describe other tissues as entering into the composition of animal bodies, such as the serous and mucous membranes, the different varieties of the fibrous tissues, the cartilages, the osseous tissue, &c.; but, according to all appearance, these varied tissues are only modifications of the *utricular* or *connective.*

§ 20. These tissues, differently combined, and affecting a variety of forms, constitute the different *organs* by which the faculties of animals are exercised. The term *apparatus* is applied to an assemblage of these organs, and that of *function* to the action of a single organ or of many. The apparatus of locomotion, for example, means the assemblage of organs, whatever they be, required for the *function* of locomotion—or motion from place to place. The structure of animals varies, then, with their faculties and mode of life; and generally it may be said, that the more varied the functions are in any animal the more complex will be its structure.

CLASSIFICATION OF THE FUNCTIONS OF ANIMALS.

§ 21. The functions of animals have a relation to two objects,—namely, 1. The conservation or preservation of the individual; 2. The conservation of the race. Of the former, some have reference chiefly to the support and nourishment of the body; others place the individual in relation to surrounding objects. Hence the division of the functions into three great classes,—those of *nutrition, relation,* and *reproduction.* The first and last of these collectively have been called *vegetative life:* the functions of relation, physiologists are agreed to call *animal life*, as being peculiarly the attributes of animals; nutrition and reproduction are functions which animals have in common with plants.

Each of these great physiological divisions is subdivided in its turn into several others, all tending towards one end; thus, the *nutrition* of an animal is accomplished only by the aid of several functions, such as digestion, circulation, respiration, &c.: digestion, in its turn, resolves itself into mastication, insalivation, deglutition, the transformation of the food into chyme, the extraction of the chyle contained in the chyme, the absorption of this chyle, and the expulsion from the body of the residue of the aliment; finally, these very acts of mastication, deglutition, &c., are all the results of divers phenomena dependent on various organs and functions.

§ 22. The utmost variety prevails in the organization of different animals. In some, the functions are simple; and this implies a harmonious simplicity of the organs. In others, complexity is the law. Between the mode of existence and the mode of organization of each being, there is the most admirable *accord.* The proofs will be given in a future part of this work.

The history of the functions of animals will now engage our attention, and first, of the function of nutrition.

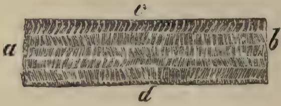

Fig. 1.

Diagram taken from the "Text Book of Physiology," by Valentin,* intended to show that every part of an organ is a mass which is traversed by interstices in all directions. If a liquid body presses on *c*, while an elastic one is present at *d*, it also renders them capable of serving as a filter.—R. K.

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* "A Text Book of Physiology." By Valentin. Translated by Dr. Brinton. H. Renshaw, Strand.

HISTORY

OF THE

PRINCIPAL FUNCTIONS OF ANIMALS.

I.—OF THE FUNCTION OF NUTRITION.

§ 23. The nutrition of living beings consists in the introduction of foreign matters into the interior of the tissues, and the fixation, assimilation, and organization of the matters so introduced. Every living animal is also the seat of a kind of slow combustion, causing the unceasing destruction of a certain quantity of organic matter. The matter thus destroyed, being useless or even hurtful to the economy, is expelled from it.

It is evident, then, that the first condition necessary for the due performance of this molecular composition and decomposition, is the faculty of *absorption*, by which the molecules are attracted and introduced into the centre of the tissues. It is a function common to all living beings.

§ 24. In plants, this single faculty suffices for the introduction from without of all matters requisite for their nourishment. With animals, a portion only is directly introduced into the tissues; but a great portion requires being elaborated by a process called digestion, by which the nutrient molecules are fitted for absorption. This faculty of digestion forms one of the characters which best distinguish animals from plants.

§ 25. The liquids thus absorbed spread wherever they are required, the distribution being in some effected slowly, in a way analogous to the absorption. In others, by far the most numerous, the distribution of the nutrient liquids is accomplished rapidly by the establishment of currents, which serve also to remove the molecules eliminated from the organs.

Thus originates another function, the circulation of the blood, and another apparatus of organs by which this is performed.

§ 26. We have alluded to a kind of slow combustion which takes place in the interior of animal bodies. This is effected by means of the oxygen of the atmosphere which is unceasingly absorbed by means of *respiration;* and it is by the same function of *respiration* that animals get quit of the matters thus consumed.

§ 27. The products of the respiratory combustion, as well as the matters eliminated from the tissues, and which, having become as it were foreign to the economy, require to be removed from it, give rise, by this necessity, to a function the opposite of absorption—that of *excretion.* The character of this process varies according to circumstances. It is called *exhalation,* when the liquids escape as it were mechanically; *secretion,* when particular liquids whose nature differs from the nourishing fluid are formed by a kind of chemical action. By these two ways the economy elaborates the particular juices necessary for the exercise of all the functions, whilst at the same time it expels all that is useless or injurious to it.

§ 28. The creation of the living matter destined to augment the mass of the tissues or to replace the parts which have been destroyed, is a process or work which the physiologist ought not to confound with any of the preceding phenomena; it is the act by which the organism fixes in its interior a foreign matter, organizes this matter, and develops in it vital properties. The function is called *assimilation.*

Thus the functions of nutrition consist essentially of absorption, digestion, circulation, respiration, exhalation, secretion, and assimilation. We shall now consider these great acts of vegetative life.

OF ABSORPTION.

§ 29. By absorption is meant the act or faculty by which animals suck up and imbibe, as it were, into the mass of their humours the substances which surround them, or which are deposited in the interior of their bodies.

The existence of such a faculty may be very readily proved. Plunge a frog into water, in such a way, however, that none can enter by the mouth; notwithstanding, the weight of the animal after a time is sensibly increased. Now this increase, which under favourable circumstances may reach a third of the weight of the animal, can depend only on the absorption of water by the surface of the body.

If water be introduced into the stomach of a living dog, and the entrance to and exit from the organ be secured with ligatures, still the liquid will disappear, absorbed by the walls of the stomach, and so mingle with the blood; and yet there exist neither in the stomach nor external integuments any pores leading directly to the vessels containing the blood. The pores observable on the skin lead merely to little cavities intended to secrete various humours or to form the hairs. Thus the tissues forming these organs (the skin and stomach) are permeable to liquids, and this is the case with all the other structures of the body.

In fact, in living as well as in dead bodies, the tissues uniformly imbibe surrounding fluids, and are traversed by them with more or less facility.

§ 30. *Mechanism of Absorption.*—It is on the permeability of the solid parts of animal bodies that the function of absorption depends. The penetration of fluids into the interior depends on a peculiar force or power acting on them. Capillary attraction contributes powerfully to effect this penetration of external liquids, but it is not the only force or power causing this phenomenon; another was discovered a few years ago by Dutrochet, and called by him *endosmose*. If, into a little membranous sac, surmounted by a tube, water, holding gum in solution, be poured, and the apparatus be then placed in pure water, as in Fig. 2, the water will be found to rise in the tube to a considerable height. Here is then an evident absorption of water through the walls of the sac. Next reverse the experiment, by filling the sac with pure water, and placing the apparatus in gum-water, and the sac will empty itself instead of absorbing more, the pure water passing through its walls in the inverse direction. Now this phenomenon has the greatest analogy with what takes place in living bodies, and partly explains it; for the purer liquids from without pass readily through the spongy tissues of animal bodies, whilst the denser material within passes with more difficulty in the opposite direction. Hence the accumulation within, which could not take place if both passed with equal facility, and established an equilibrium. Such an equilibrium is prevented by the union of the purer liquid with the denser liquid within the membranous sac in the one case, and within the animal body in the other. Hence the elevation of the gum-water in the tube, and the increase of weight in the living animal, both being due to one cause, namely, *endosmose*.

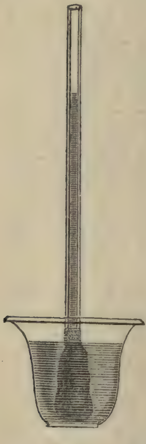

Fig. 2.

§ 31. Organized bodies are represented by the sac as seen in Fig. 2. They are placed in a surrounding medium more fluid than that existing in their interior. Hence they absorb.*

§ 32. *Organs of Absorption.*—In certain animals low in the scale of life, absorption consists merely in the process we have just described. In these animals there exists no regular circulation in the interior of their bodies; but in the higher classes of animals the function is more complex. The fluids imbibed, as described above, pass into the interior of the vessels, and there mingle with the nourishing fluids of the animal, and thus mingled and united they pass with the blood to certain parts of the economy, wherever, indeed, that penetrates. Thus the function of absorption becomes divided as it were into two acts; the first, simply the act of imbibition through the tissues; the second, that of circulation through the interior of the animal.

§ 33. In all animals the principal agent for this transportation of the matters absorbed to various parts of the body is the blood, acted on by the heart, to which the liquids are conveyed by the veins; and thus it happens that in the great majority of cases these vessels play an important part in the function of absorption.

§ 34. In many animals there exist only sanguiferous vessels, and the function is performed by them alone. In others however, and especially the more highly organized, there exists another order of vessels, destined to absorb certain

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* The passage of liquids through various membranous coverings is a complex subject, still open to inquiry. Thus, if spirits of turpentine be enclosed in a glass jar, as in the setting up of anatomical preparations in the usual way, by means of several layers of bladder, tin-foil, &c., it will in time escape, and, covering the exterior of the glass, obscure the object within. If, on the other hand, only a single layer of bladder be used, none of the turpentine will escape. This curious fact was accidentally discovered by my brother.—R. K.

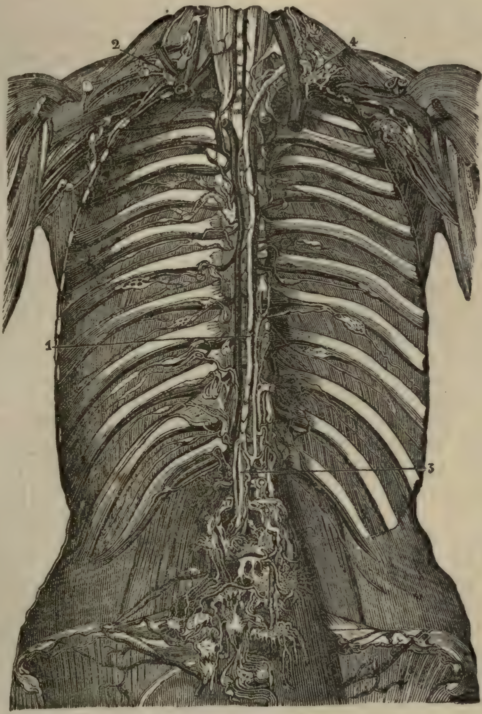

Fig. 3.—Thoracic Canal.*

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* Thoracic cavity and upper part of the abdomen, laid open to display the posterior wall.—1. The thoracic duct, or canal, lying on the front of the vertebral column, by the side of the azygos vein.—3. Origin of this canal from the lacteal vessels, and from the common lymphatics proceeding from the lymphatic ganglions of the abdomen.—4. Termination of the canal in the left subclavian vein, near its junction with the left jugular.—2. Large lymphatic vessels arising on the right side of the head, and terminating in the right subclavian and jugular veins. (Figure copied from the *Traité d'Anatomie Humaine*, by M. Sappey.)

substances. These are called *lymphatics*, and they constitute a system of vessels to which the name of *absorbents* is more especially given.

They originate in extremely fine tubes or roots in the animal tissues, and collecting into larger vessels, ultimately terminate in the veins. Their walls (*parietes*) are extremely fine, and they frequently communicate with each other. The point of union is called an *anastomosis*. In man and in the mammalia they exist almost everywhere throughout the body, and they terminate at last in a single trunk, *the thoracic canal* (Fig. 3), which, commencing in the abdomen, passes through the thorax, to terminate finally in the left subclavian vein. But others pass into veins in their course, and many on the right side unite to form a short trunk which enters the right subclavian vein. In their course, the lymphatics pass through small rounded bodies, called *lymphatic glands*. The use of these is altogether unknown. These so-called glands abound in the axillæ, the groins, and in the cavities of the chest and abdomen, the neck, &c. (Fig. 35). Moreover, in the interior of these vessels there exist numerous valves, which permit the contents to circulate only in one direction, that is, towards the heart.

These vessels have been proved to exist in mammals, birds, reptiles, and fishes. In some reptiles and batrachia they are even more complex than in the higher animals, having connected with them contractile reservoirs, which pulsate or contract like hearts, and may be so regarded.

§ 35. The liquid they contain is called *lymph*. When not mingled with the products of digestion, it is slightly yellowish, and transparent. Examined by means of the microscope, spherical colourless globules are discovered in the lymph, smaller than those found in the blood; left to itself it coagulates, but less strongly, like the blood. Its composition, as shown by chemical analysis, is water, albumen, fibrin, and various salts.

Little is known of the movements of the lymph in the vessels. It ascends in the thoracic duct with considerable force, and always in one direction.

§ 36. Absorption by means of these vessels in certain organs may be readily demonstrated by observation on living animals. Lay open the cavity of the abdomen in an animal when digestion is going on, and the lacteals will be seen filled with a milky-looking fluid, the chyle; hence this portion of the lymphatic system has been called lacteal. In an animal fasting, this fluid not being present, these vessels are colourless.

[The lacteals may readily be seen in an animal just dead, by spreading out the membrane supporting the small intestine, and looking attentively at it. When the chyle has left them, which it does even after death, they are not so readily detected, and may be mistaken for small veins, or *vice versâ.*—R. K.]

Absorption by the veins may also be demonstrated in the same way, that is, by experiments on living animals.

§ 37. *Circumstances influencing Absorption.*—The first condition essential to absorption is the permeability of the tissue interposed between the substance to be absorbed and the liquids which form the means of transport to its destination; so that, *cæteris paribus,* absorption is rapid in the direct ratio of the sponginess and softness of the tissue. It may also be laid down as a principle, that absorption is rapid in a direct ratio to the vascularity of the tissue. As absorption is mostly effected by the veins, the abundance of these necessarily influences the function. Thus, anatomically, may almost be predicated the enormous differences in the rapidity with which various substances are absorbed by different tissues. Of the lungs, for example, pre-eminently so spongy and vascular, it might be predicted that absorption would in them be most rapid; and this is in fact the case.

The *cellular tissue*, forming the basis and connecting medium of most of the organs, is also, by its soft and spongy nature, the seat of rapid absorption, but less so than the lungs, as being much less vascular.

The skin, on the other hand, being but little vascular, and being at the same time covered by the almost impermeable *epidermis* or *scarf-skin*, explains why we can handle dangerous poisons with safety, so long as the *epidermis* is unbroken.

A state of *plethora* (from πλήθω, I fill) exercises an influence over the rapidity of absorption. The quantity of liquids an animal body may contain is limited, and desiccation also has its limits. The nearer the animal may be to the point of plethora or saturation, the less will it absorb.

Thus, poison administered to two living dogs will influence the one in a state of plethora much more slowly than the other which has been previously reduced by a copious bleeding; and finally, *cæteris paribus*, absorption will be less rapid as the liquids to be absorbed are less liquid and less fitted to moisten the tissues.

OF DIGESTION.

§ 38. One of the principal means by which the absorption of the matters necessary for the nutrition of animals is effected, is a cavity communicating with the exterior, and into which the food is introduced.

§ 39. *Aliments.*—We restrict the meaning of this term, for the sake of clearness, to those substances which, being introduced into the stomach, are absorbed only after being digested. It is needless to remark that food and air are essential to the support of life.

The want of food is indicated by the painful sensation we call *hunger:* its seat is in the stomach. This want and its sensation may be diminished and kept off by rest, sleep, and by whatever retards the vital movements. On the contrary, it is increased by activity, fresh air, and by the use of bitters. Hybernating animals, which sleep during winter, eat not, so long as the lethargy continues; and cold-blooded animals, as fishes and frogs, can live in despite of a long-continued abstinence. But man and other hot-blooded animals—and more especially, for an obvious reason, the young—perish speedily when food is withheld, even for a comparatively short time. In Dante's celebrated episode of the destruction of the Ugolini family by starvation, the youngest perished first.

All alimentary substances are furnished by the organic kingdoms—animal and vegetable; whatever be their origin, they may be divided into azotized elements, amylaceous or sweet, and fatty bodies. These substances differ in their nutrient qualities; and it is a fact, proved by many curious experiments, that a certain number of different substances is essential for the support of life.

Thus, rabbits fed upon only one article of food, as hay, wheat, cabbage, carrots, &c., die in about fifteen days; whilst fed on these articles combined or given in succession, they live and thrive.

A hygienic law, then, is, the diversity and variety in respect of food; and experience and experiment agree as to this.

It has been proved experimentally, that substances (such as sugar, oil, gum, fat) devoid of azote do not nourish, however much they may be varied. The use of a certain number of substances, such as the muscular flesh—albumen and the gluten found in wheat, seems essential to the support of life.

§ 40. *Digestive Apparatus.*—The object of digestion is, 1st, to separate the nutrient part of the aliment from the non-nutrient (*fæces*); 2nd, to convert the nutrient part into a liquid fit to mingle with the blood and thus to nourish the body.

This elaboration of the food takes place, in animals, in a cavity more or less ample, communicating with the exterior, and into which the food is received, and from which the non-nutrient portions are expelled. Vegetables require no such apparatus. The cavity to which we allude is called the *digestive.*

§ 41. In certain animals the digestive cavity is simply a pouch, having but a single entrance by which the food is received and the non-nutrient portion is expelled (Fig. 4. *a*); and this arrangement prevails in most of the polyps, asteriæ or sea-stars; and many other animals more complex in their structures also show this arrangement. But, for the most part, the digestive tube or canal has two openings—an entrance for the food, and an exit for the non-nutrient part, the *mouth* and the *anus.*

The alimentary canal thus forms a tube, dilated at intervals, and with two openings (Fig. 5). The more important of these dilatations is called the stomach. This cavity is sometimes single, as in the carnivora; sometimes quadruple, or at least complex, as in the herbivora; and the reason assigned for such a com-

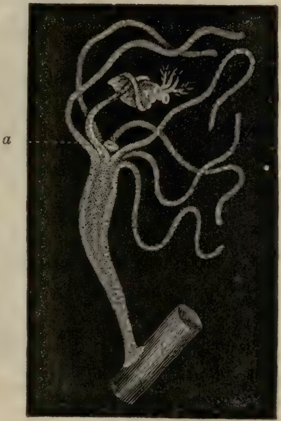

Fig. 4.—Hydra, or Fresh-water Polyp.

plexity is, that vegetable food, being less easy of digestion, requires a longer sojourn in the stomachal cavities.*

§ 42. A *membrane*, called *mucous*, lines the digestive cavity throughout. It is analogous to the skin, with which it is continuous, but differs in structure. It is much softer, and in place of an epidermis is protected on its exposed surface by a *reticular* tissue, soft and turgid, called *epithelium*. Finally, it is more vascular than the other, and abounds with secreting pores. Externally, it possesses a muscular tunic intended to act on the contents of the tube. A serous membrane, large and translucent like all serous membranes, invests

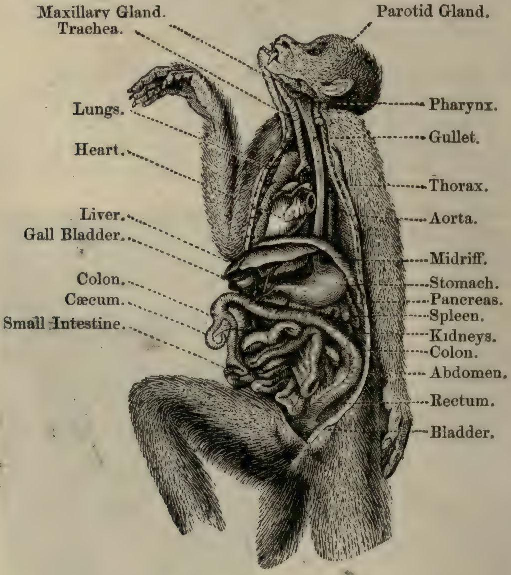
Maxillary Gland.
Trachea.
Parotid Gland.
Lungs.
Pharynx.
Gullet.
Heart.
Thorax.
Liver.
Aorta.
Gall Bladder.
Midriff.
Colon.
Stomach.
Cæcum.
Pancreas.
Small Intestine.
Spleen.
Kidneys.
Colon.
Abdomen.
Rectum.
Bladder.

Fig. 5.—Digestive Apparatus of an Ape.

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* The stomach is probably single in all animals, being simply subdivided in some into different compartments. In whales, though strictly carnivorous animals, the stomach is extremely complex.—R. K.

it externally in the abdomen, serving to fix it in its place, and to facilitate its movements.

§ 43. The digestion of the food is effected mainly by the action of different humours, which the food imbibes whilst passing through the alimentary canal. These humours are chiefly the secretions from certain bodies, called glands, situated around the digestive tube, and destined to pour into its cavity various liquids or secretions. The number of these secreting organs varies in different animals, but generally, they are sufficiently numerous. The more important are the salivary and gastric glands, the liver and the pancreas.

§ 44. Finally, to facilitate the action of the digestive juices on the food, it is useful to divide it mechanically. To effect this, nature employs, as is usual, various means. Sometimes the food is compressed merely by the walls of the digestive tube; in other animals, as in birds and crabs, the food is crushed to pieces in the stomach; in others, as in man, the mechanical division of the food is effected by means of the *teeth* situated in the mouth, at the commencement of the alimentary tube itself. These are the masticatory organs and apparatus.

§ 45. Thus the digestive tube, extremely simple in some animals, is in others very complex, extending from nearly one extremity of the trunk or torso to the other. Nevertheless, its greater part is lodged in the cavity of the abdomen (Fig. 5), which in mammals is separated from the *thorax* by a muscle called the diaphragm, or midriff. Inferiorly it terminates in the *pelvis* (Fig. 90), the interior of which possesses a sort of muscular floor. Behind, the cavity is shut in by the spinal column, and at the sides by broad muscles extending from the thorax to the pelvis. Internally this cavity is invested by the serous membrane called peritoneum, by portions of which (the mesenteries) the bowels are maintained in their place, whilst other portions, extending beyond the margins of the stomach and bowels, and thus floating in the cavity of the abdomen, are called epiploons and epiplooic appendages.

The various portions of the alimentary tube thus formed and located receive different names. Its first part is called the mouth; the cavity following it, the pharynx; next follows the gullet; then the stomach; and this is followed by the small intestine, itself subdivided into three portions, the duodenum, jejunum, and ileum. After this follows the large intestine, terminated by the anus.

§ 46. *Acts of the Digestive Function.*—The phenomena which take place in the different portions of the digestive tube constitute a series of acts or functions all tending to one end. They may be thus classed:—1. There is the prehension of the food; 2. The mastication; 3. The insalivation; 4. The deglutition; 5. The chymification, or stomachal digestion; 6. The chylification, or intestinal digestion; 7. Defæcation; 8. The absorption of the chyle.

Let us now examine these organs and their acts successively, in man and in the animals which most approach him.

Prehension of the Food.

§ 47. That this act varies in different animals is evident. Man employs the hands and mouth. Anatomically speaking, the term *mouth* includes not only the opening so-called, but the cavity into which it leads. This cavity is very complex, but may be briefly described as having two orifices, one externally, on the face, the other situated deeply, and leading to the pharynx. Its boundaries are the palate above, the tongue and floor of the mouth below; at the sides the cheeks; behind, the moveable palate limits its extent, and serves the important purpose of isolating it at times from the pharynx, and of protecting the posterior nostrils. In man and in many other animals the food is placed in the mouth by the hands or anterior extremities; the lips retain it when so placed.

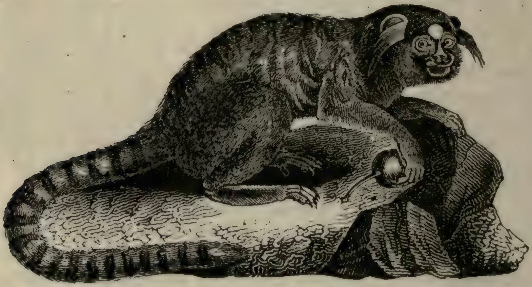

Fig. 6.—Jacchus Penicillatus, Ouistiti à pinceau, Marmoset.

Certain animals introduce the food into the mouth by means of a long and protractile tongue. In others, this act is accomplished by means of a prolongation of the nose, as in the elephant (Fig. 7); or by means of feelers (*palpi*) surrounding the mouth, as in insects (Fig. 8), whilst similar organs are called tentacula in the mollusca (Fig. 10), the polyps (Fig. 4), &c.

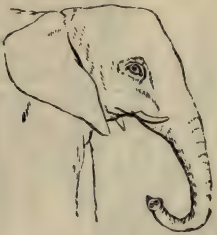

Fig. 7.—Head of the Asiatic Elephant.

§ 48. The prehension of the liquid aliments or drinks is effected in two ways. Sometimes the liquid is poured into the mouth, and allowed to fall into it by its own weight; in others, it is sucked up by the mouth, either by the dilatation of the thorax or by the action of the

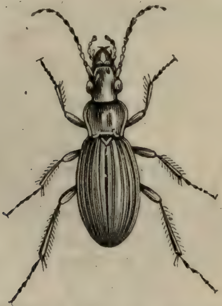

Fig. 9.—Carabe, a Beetle.

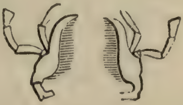

Fig. 8.—Jaws of the Beetle.

tongue acting as a piston. Sucking is effected by this last method.

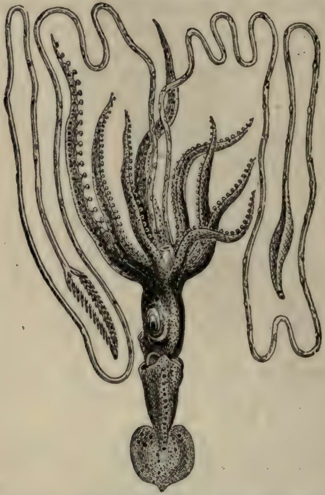

Fig. 10.—The Mollusk, called Calamary; a species of Cuttle Fish; the Loligo Sagittarius; very common in the Frith of Forth.

Certain of the lower animals are destined to nourish themselves solely by liquids found in plants or in the bodies of other animals, on which they live as parasites. Many insects are thus provided for; and their mouth, instead of presenting the ordinary structures, constitutes a kind of tube or a very elongated sucker, by means of which they draw up the liquids they require (Fig. 11). The details of this curious structure will be explained when treating of the history of insects.

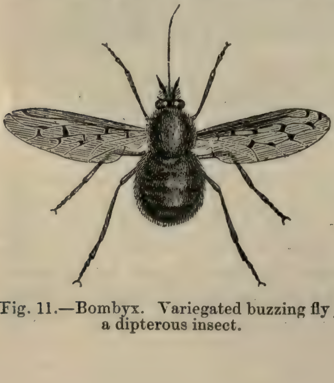

Fig. 11.—Bombyx. Variegated buzzing fly; a dipterous insect.

The liquid aliment quits the mouth, and descends immediately into the stomach through the pharynx and gullet. The solid part remains for a time in order to undergo the action of mastication.

Mastication.

§ 49. Mastication is performed by the teeth.

The Teeth.—These organs are extremely hard substances, resembling bone, firmly fixed into the alveolar edges of either jaw, and so as to act upon each other, or rather upon whatever is placed between them. In man, whom we select as the example, each tooth is formed in a little membranous sac lodged in the thickness of the jaw itself (Fig. 14). This sac, which is named the *dental capsule,* is composed of two vascular membranes, and encloses in its interior a small pulpy germ or centre, similar to a granulation, into which ramify numerous fine nerves and vessels (Fig. 13). This pulp, called also the *germ* or *bulb* of the tooth, serves to form the tooth, gradually becoming elongated and approaching the free edge of the jaw, which it soon pierces, and so appears externally. The portion thus denuded and exposed beyond the edge of the jaw is called the *corona* of the tooth, whilst the portion called *root* remains imbedded in the jaw like a nail driven into a board. The osseous cavity thus lodging the tooth is called the *alveolus,* and the point of union of the corona and root is called the neck of the tooth. When the dental bulb is fixed to the bottom of its capsule by one or more pedicles, there arrives a moment when the hard part of the tooth deposited on the surface of the bulb surrounds it on all sides, compressing its nourishing vessels so as to cause their obliteration. The tooth ceases then to grow, the bulb wastes away, and a

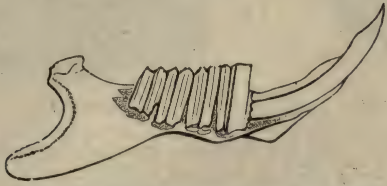

Fig. 12.—Lower Jaw and Teeth of the Rabbit.

central cavity alone indicates the place of this organ. But when the bulb does not exhibit this arrangement; when it is not pedunculated, and when the tooth forms only on the upper surface, the growth of the tooth ceases not, and no central cavity is found in its interior.

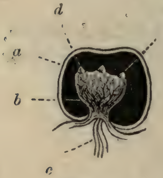

Fig. 13.*

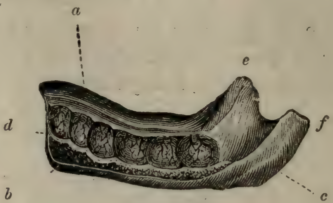

Fig. 14.†

The large teeth found in the front of the mouth of the rabbit (Fig. 12) offer an example of this kind of dentition: and if their length does not constantly increase, it is because they are worn down by trituration on their cutting edge in proportion as they grow at the base.

§ 50. Teeth are composed of various structures. The substance forming the greater part of the tooth, underneath, is called the *ivory* or *dentine*. The dense covering of the corona is called *enamel*: A third substance is occasionally found towards the extremity of the roots, or even enveloping the enamel and corona (as in the ox), to which the name of *cement* or *cortical substance* has been given.

The ivory of the tooth is composed of an animal matter analogous to gelatine, of phosphate of lime (in the proportion of about 64 to 100 in the adult human tooth), of carbonate of lime (amounting nearly to $\frac{5}{100}$ parts), and of a small quantity of phosphate of magnesia. The enamel, which differs somewhat in colour from the dentine or ivory, and which is hard enough to strike fire with flint, shows on analysis slight traces of an animal substance. The phosphate of lime in its composition amounts to $\frac{9}{10}$ths. The cortical substance or cement scarcely exists in the human teeth; but in the teeth of oxen, in which it abounds, it furnishes, by chemical analysis, 42 per 100 of organic matter, 50 per 100 of phosphate of lime, and 4 per 100 of carbonate of lime.

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* Section of a dental capsule. *a*, capsule; *b*, bulb or germ; *c*, blood-vessels and nerves entering the germ; *d*, first rudiments of the ivory of the tooth.

† Lower jaw of a very young infant. The outer table of the jaw has been removed to expose the capsules of the teeth enclosed in its interior. *a*, the gum; *b*, lower edge of the jaw; *c*, angle of the jaw; *d*, dental capsules; *e*, coronoid process; *f*, condyle of the jaw.

In the ivory of the teeth of man we discover, by means of the microscope, a multitude of *flexuous* branching tubes of extreme tenuity (called *Haversian canals*), which open or terminate in the central cavity; these tubes contain calcareous matter; they run towards the surface of the tooth, and their divisions terminate frequently in little cavities bearing a close resemblance to the little cells found in the ordinary osseous tissue. The *enamel*, examined under the microscope, exhibits a multitude of fibres, or rather hexagonal prisms, in appearance crystalline, closely pressed against each other, and directed perpendicularly towards the surface of the tooth. Finally, the cortical substance is characterized by the presence of a great number of osseous cellules, and of irregular calciferous tubes. These tissues are not all met with in the teeth of all animals; the enamel and cortical substance are frequently absent in fishes; and occasionally the dentine, instead of containing a single medullary cavity, contains several.

§ 51. The teeth, in some animals, instead of being contained or fixed in the alveolar cavities (sockets), unite by their base with the jawbone or maxilla, becoming, as it were, a part of it: this happens in many fishes, and occasionally the teeth, instead of resembling bones, offer merely the consistence of horn. Finally, in the whalebone whale (Fig. 16) the teeth seem to be replaced by large flexible plates of whalebone (*fanons*, Fig. 15); and in other

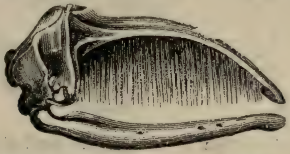

Fig. 16.—Osseous Head of the Whale,* with the Whalebone present.

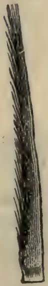

Fig. 15. The Whalebone. (Fanon.)

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* Mysticetus; Greenland Whale, or Whale of Commerce. Rudimentary teeth exist in the fœtus of the whale in both jaws.—R. K.

animals, even mammals, are wholly wanting, as in the anteater (Fig. 29).

§ 52. In animals which do not masticate, but merely seize their prey with the teeth, as in crocodiles, and many other reptiles, all the teeth resemble each other: they have the form of hooks or cones: but in animals which masticate, the teeth have different forms and uses.

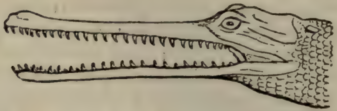

Fig. 17.—Head of the Gavial or Gangetic Crocodile.

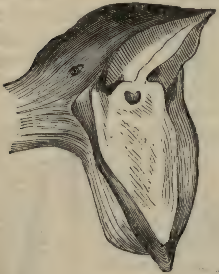

Fig. 18.—Mouth of Balænoptera Rostrata, or smaller Rorqual.*

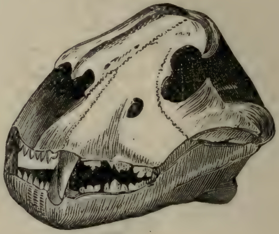

Fig. 19.—Skull of the Lion.

Thus, in man and most mammals there exist three kinds of teeth: 1. The teeth called *incisive*, which have a sharp cutting edge. 2. Conical teeth, which in many animals project beyond the plane of the others; these are the *canine* teeth. 3. Others, called *molar*, whose broad and irregular surface points out their use in the trituration of the food.

The mode of implantation of these teeth in the jaws differs, as well as the form of the corona, being, in fact, in accordance with their uses. The incisive, intended only to cut or divide the food, have but a single short root; the canine penetrate much more deeply into the jaws than the incisives; and the molar, called on to undergo still stronger pressure, are firmly fixed by two or three roots into the alveolar cavities.

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* The mouth of the smaller Rorqual; it has no teeth in either jaw; the food is caught by the whalebone in the upper jaw. From a sketch made from life by my former assistant, E. J. Forbes.—R. K.

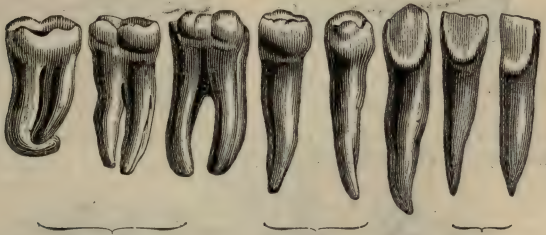
Large Molar.
Not preceded by any deciduous teeth.
Small Molar.
Canine.
Incisive.
Preceded by deciduous teeth.

Fig. 20.—Human Teeth.

§ 53. The harmony of organization between the teeth and their uses is such, that in general it is easy, by a sight of the teeth of an animal, to say to what class it belongs, and to predict much, *à priori*, as to its nature. Thus, in carnivorous animals the molars are not grinding teeth, properly so called, but present a sharp edge, dividing the prey like a pair of scissors (Fig. 21); in insectivorous animals the teeth have

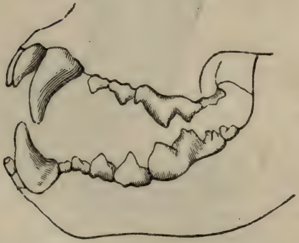

Fig. 21.—Teeth of a Carnivorous Animal.

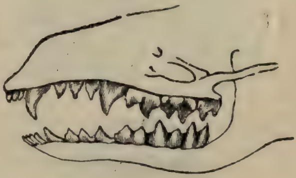

Fig. 22.—Teeth of an Insectivorous Animal.

a tuberculated surface, rough, with conical points, so arranged as to lock into each other. In the frugivorous, living on soft fruits (Fig. 24), these teeth are simply provided with rounded tubercles; in the herbivorous these teeth have a broad, rough surface, resembling a millstone (Fig. 23).

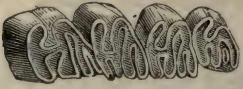

Fig. 23.—Teeth of an Herbivorous Animal.

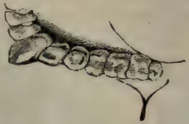

Fig. 24.—Teeth of a Frugivorous Animal.

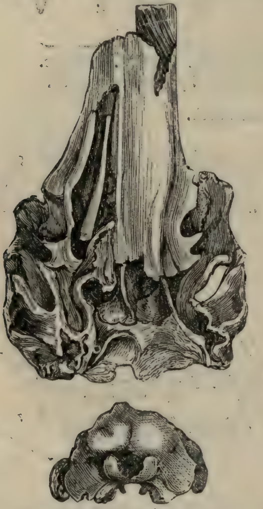

Fig. 25.—Skull of the Narwhal.* Lower surface.

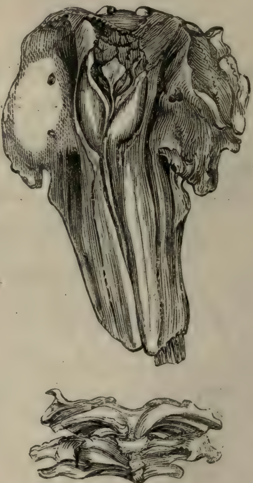

Fig. 26.—Skull of the Narwhal. Upper surface. Upper cervical vertebræ.

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* This and the two following figures illustrate the singular fact of the development of only one of the incisives in the upper jaw; the other remains imbedded in the osseous tissue of the maxilla. The figures also show the remarkable want of symmetry in the cranium of certain of the cetacea.—R. K.

[The law based on a harmony of organization between the teeth and their uses and between the *teeth* and other organs of the body must be used with great caution. A universal law of organic harmonies no doubt exists, but its true nature has not yet been discovered. Cuvier, who boasted so much of this law, nevertheless used it with the utmost caution, and never trusted wholly to it.—R. K.]

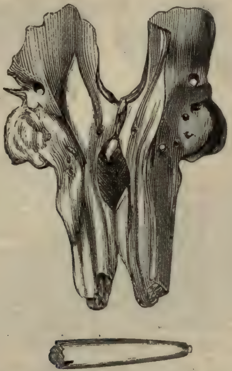

Fig. 27.—Skull of the young Narwhal, before the development of the left incisive, which sailors call its horn.

Of all the teeth the molars are the most useful: hence their presence is much more frequent than the incisives or canines. These latter, for an obvious reason, are never wanting in the carnivora; but they are not unfrequently absent in the herbivora.

[The reason is not at all obvious, even where it is the case; such teeth are wanting in the strictly carnivorous cetacea.—R. K.]

The canine in some animals grow to a large size, and become instruments of attack and defence (Fig. 28).

§ 54. At birth it is seldom that the human teeth have cut the gums; they appear usually from six months to a year after birth. The teeth which first appear are called *milk teeth*, or deciduous, as destined to be thrown off and to be replaced by others. They are twenty in number, namely, in each jaw ten—viz., four incisives, one canine, and two molar.

About seven years of age these begin to fall or to be thrown off, and to be replaced by another series of teeth, situated in capsules imbedded more deeply in the jaws; their roots therefore are longer, and their insertion firmer.

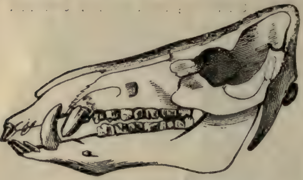

Fig. 28.—Head of the Boar.

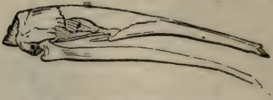

Fig. 29.—Head of the ant-eater. Myrmecophaga Jubata.

The teeth of the second dentition are more numerous than those of the first: they are thirty-two in number, sixteen in each jaw; namely, four incisives, two canine, four small or false molar, having each two roots, three true molars situated behind these, and having each three roots (Fig. 20).

In old age these permanent teeth fall as did the deciduous, but they are not replaced.

§ 55. *Mechanism of Mastication.*—The teeth, the passive instruments of mastication, are put in action by the muscles of mastication acting on the jaws. The upper jaw, forming a fixed portion of the head in mammals, moves only with the head; but the lower, by means of its articulations, acts readily and powerfully, and by means of many muscles, and with the aid of the tongue and cheeks, forces the food in such a way between the surface of the grinding teeth as to expose it fully to their action.

§ 56. This operation is an important one, inasmuch as the more the food is masticated the easier will be the digestion. When such instruments are wanting in animals whose food still requires trituration, this is effected by other means. The gizzard, for example, in many birds is sufficiently strong to answer this purpose.

Insalivation.

§ 57. Whilst the food is undergoing trituration in the mouth, it imbibes saliva, which sometimes even dissolves it.

§ 58. The saliva is formed partly in little mucous cavities hollowed out of the mucous membrane of the mouth, partly by glands situated around this cavity, and communicating with it. These glands are composed of small granulations, agglomerated. In man there exist three salivary glands on each side, placed around the lower jaw; the parotid, the submaxillary, and the sublingual. They have each an excretory duct, by which their secretions are poured into the mouth in

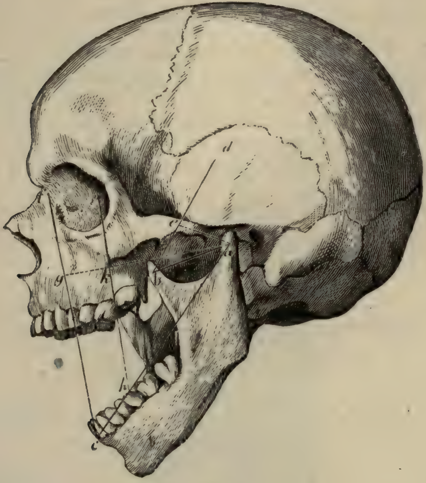

Fig. 30. From Valentin.*

variable quantities. The follicles of the mucous membrane of the mouth are disseminated partly over the surface of the tongue and cheeks, and partly collected into two groups, situated in the isthmus or passage by which the mouth communicates with the pharynx. These little masses of follicles are called amygdalæ, or tonsils.

The mixed saliva coming from these various sources is composed of 993 parts of water to 1000 of saliva. In addition, there exist a peculiar principle called *ptyaline* and *animal diastase,* various salts, as sea salt or chloride of sodium, tartrate of soda, and a little uncombined soda, rendering the saliva alkaline.

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* In the act of mastication the lower jaw (*a*, *i*) is pressed against the immovable upper one (*k*, *g*). Since the upper and lower rows of teeth are arranged symmetrically, it is only the corresponding masticatory surfaces of opposed teeth which work upon each other.

The saliva thus mixed with the food facilitates mastication, assists in deglutition, and obviously aids in the digestion of some kinds of food.

Deglutition.

§ 59. In mammals, between the buccal cavity and the pharynx, is a moveable muscular partition, the *pendulous palate* (Fig. 31), which, during mastication, separates the two cavities from each other; but so soon as this is accomplished, the alimentary mass or bolus being pressed backwards by the tongue, the pendulous palate is drawn upwards and backwards, so as to permit of the passage of the food or drink through the isthmus into the pharynx. At this point deglutition commences, the term being applied to the

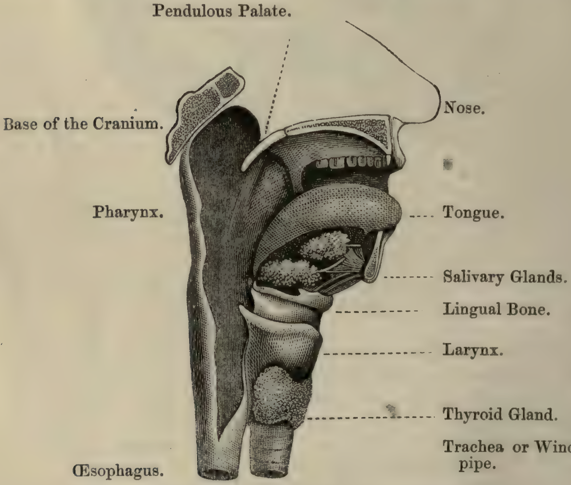
Pendulous Palate.
Nose.
Base of the Cranium.
Pharynx.
Tongue.
Salivary Glands.
Lingual Bone.
Larynx.
Thyroid Gland.
Trachea or Wind-pipe.
Œsophagus.

Fig. 31.—Vertical Section of the Mouth and Throat in Man.

passage of the food and drink from the pharynx, by the gullet, into the stomach.

§ 60. The pharynx (Fig. 31) is the cavity immediately following the mouth, and communicating with it by the isthmus. It receives the food from the mouth, and the air passes by the same passage when the nostrils are closed or obstructed. Seven openings lead to or from this cavity, the posterior nostrils, namely, being two; the Eustachian tubes leading to the ears, two; the opening to the mouth, one; the opening of the gullet, one; the aperture leading to the lungs through the larynx and windpipe, one; seven in all. The trachea is the tube leading into the chest, surmounted by the larynx. By this tube the air passes into the lungs, placed in the thorax, and the œsophagus or gullet passes through the chest and enters the abdomen to expand, as it were, into the stomach. By this tube the food and drink pass into that organ.

§ 61. Whilst the alimentary bolus is passing from the mouth to the pharynx, the apertures of the posterior nostrils are protected by the pendulous palate; the tubes leading to the ears by a peculiar mechanism, and by their direction; the opening leading to the larynx and air passage or trachea is protected by a cartilage of a singularly wonderful mechanism, closing the air tube hermetically whilst the food is passing over its upper surface; the gullet is then the only aperture left by which the food can escape from the pharynx, and this leads directly to the stomach. The movements and contractions required to effect these actions are numerous, complex, and quite involuntary; when disturbed, the food may penetrate into the larynx and windpipe, causing for an instant terrible distress, and certain death if not speedily relieved. Finally, the gullet being in part muscular, by its contractions the food is readily propelled into the stomach. It is almost needless to say that the gullet is nearly straight, and that the food does not descend into the stomach by its own gravity.

Stomachal Digestion or Chymification.

§ 62. The food is changed in the stomach into the substance called *Chyme*. The stomach (Fig. 32), is a membranous bag placed transversely in the upper part of the abdominal cavity, and almost immediately below the diaphragm; in man it has the shape of a bagpipe, and indeed it is with the stomachs of animals having this shape that the air reservoir of the bagpipe is made. It diminishes gradually from left to right, and is curved on itself, so that its upper edge is short and concave, its inferior, called the greater curvature of the stomach, convex and long. By an opening called cardiac (or, better, œsophageal), it communicates with the gullet; the opening leading into the small intestine is called pyloric. The walls of the stomach are very dilatable: when empty, a number of folds may be seen internally, which disappear when the stomach is full. Little follicles or cavities may be seen also. The term *pylorus* is derived

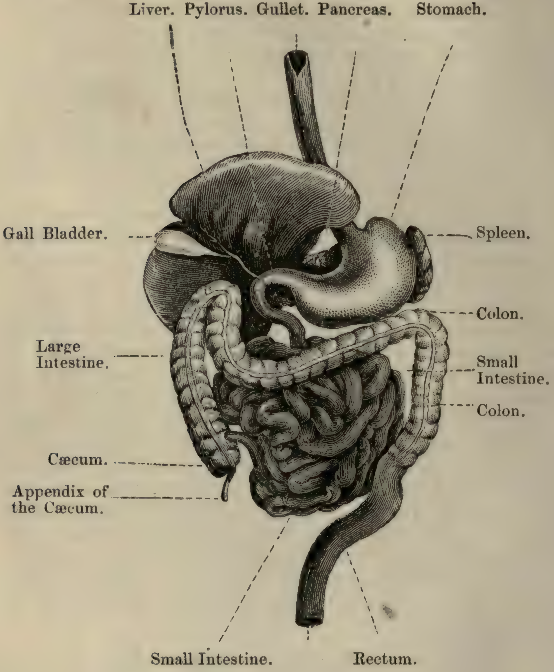
Liver.
Pylorus.
Gullet.
Pancreas.
Stomach.
Gall Bladder.
Spleen.
Colon.
Large Intestine.
Small Intestine.
Colon.
Cæcum.
Appendix of the Cæcum.
Small Intestine.
Rectum.

Fig. 32.—Digestive Apparatus in Man.

from the Greek word πυλουρὸς, a porter (πύλη, a gate, and οὐρὸς, guardian). During digestion in the stomach, the pyloric orifice is closed, and afterwards opens to allow of the passage of the chyme into the intestine; over the interior of the stomach are numerous small cavities called *gastric follicles*, which pour out upon the food the liquid they secrete.

This liquid is the *gastric juice*, the most important of all the agents of digestion, for by it the food is converted into chyme. So long as the stomach is empty, it is secreted only in small quantities; but in the organ filled with food, especially if solid, the gastric juice is secreted in abundance. Its acid properties are always well marked.

§ 63. The alimentary substances which accumulate in the stomach being pressed on by the muscular wall of the stomach and abdomen would reascend the gullet, but are prevented by the contraction of this organ. This resistance, however, is frequently overcome, as in regurgitation and vomiting. On the other hand, the contraction of the pylorus during digestion retains the food for some time in the stomach.

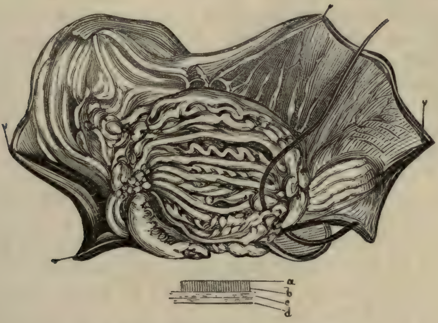

Fig. 33.—Stomach of the Porpoise.*

§ 64. The food thus retained is collected chiefly in the part called the great cul de sac of the stomach. Some of its contents, as water, alcoholic liquids, &c., are taken up or absorbed by the walls of the stomach, and thus enter the blood without further change. Others pass the pylorus unaltered, and escape with the fæces; but the greater part undergoes the action of digestion, and is by this transformed into a pulpy semi-liquid mass, called *chyme.*

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* See "Transactions of the Royal Society of Edinburgh." The Memoir referred to contains an account of the discovery of the gastric glands of the porpoise. The accompanying smaller figure gives a view of the glandular layer as it appeared under the microscope. These glands were mistaken by Cuvier for muscular fibres.—R. K.

It would appear that the alimentary fragments placed on the surface of the mass, and more immediately in contact with the walls of the stomach, imbibe the gastric juice, become acid, and soften from the circumference towards the centre. With time the whole mass undergoes this change, and becomes converted finally into a soft pultaceous greyish mass, of a faint and peculiar odour: this is the chyme, mingled with the *débris* of the food.

§ 65. *Nature of the Digestive Process.*—Prior to the experiments of Spallanzani, the true nature of the digestive process was not understood. He it was who first showed, by direct experiment, that the solution of the food in the living stomach was due to the action of the gastric juice; and this he proved, by enclosing the food in tubes of wood, perforated so as to allow of the action of the secreted liquids, but strong enough to resist the action of the walls of the stomach: thus proving that trituration was not the cause of digestion. He carried his experiments still further, for by withdrawing, by means of little bits of sponge secured with threads, a sufficient quantity of the gastric juice from the stomachs of crows and other birds, he imitated successfully the digestive process on food placed in close vessels, heated to a proper temperature.

It is evident, then, that the gastric juice is the true solvent of the food in the stomach, and a question arises, namely, to what property it owes its active power.

§ 66. Ascribed hitherto to the presence of the hydrochloric and lactic acids which always enter into its composition, the experiments of Eberle, Schwan, and Müller seem to prove the existence of a peculiar principle (*pepsin*) analogous to the action of *diastase* on tinder. But this substance or principle requires to be combined with an acid, the hydrochloric or acetic for example. It can then dissolve fibrin, coagulated albumen, and the greater number of the solid alimentary bodies; and it further produces important changes in the chemical nature of some of these bodies, as for example, in albumen.

Certain alimentary substances, as fecula and gluten, are not acted on by pepsin; and in order to be digested they require to be previously submitted to other agents. The saliva is one of these agents; and thus it is that in herbivorous animals there often exists, between the mouth and stomach properly so-called, a first cavity, intended to lodge the food whilst being mixed with the saliva. In the mammals called ruminants, this pouch, or first stomach as it has been called, is named the *paunch* (Fig. 34); and in birds, the *jabot* or crop.

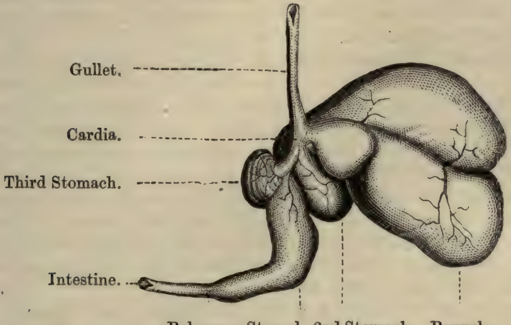

Fig. 34.—Stomach of the Sheep.

Fatty substances used as food resist the action of these juices, and pass the stomach unaltered. It is only in the intestines that they meet an agent equal to their solution.

Whilst chymification proceeds, the muscular fibres act circularly, and push the mass, at first from right to left, afterwards from left to right, towards the pylorus, by which the chyme passes on to the small intestine. This action is called *peristaltic*.

Chylification.

§ 67. *Intestines.*—The portion of the alimentary canal immediately following the stomach is called the *intestine*, (Fig. 32.) This membranous tube, variable in its capacity, is in man about seven times the length of the body. In the purely carnivorous animals it is shorter, and in the strictly herbivorous, longer than in man, who is generally considered to be omnivorous. Thus, in the lion, it is only thrice the length of the body, whilst in the ram it measures twenty-seven times the length of the animal. The reason assigned is the facility, on the one hand, with which animal substances are digested, and the comparative slowness with which vegetable substances undergo this change.

Lodged in the abdomen, the intestines are enveloped and supported by a membrane called the peritoneum; they are further subdivided into the small and large intestines, and these names are preserved, though occasionally inapplicable to the organs described.

The small intestine follows the stomach immediately, and it is in it that the digestion is completed. It forms about three-fourths of the entire length of the tract of the intestines. The smoothness of its external surface is due to its peritoneal covering; internally, its mucous membrane presents on its surface a number of villosities and of small follicles. Many transverse folds exist, projecting into the interior of the tube: they are supposed to assist in retarding the progress of the alimentary mass, and thus effecting a more complete absorption of the chyle. The villosities are considered as the means by which this absorption is effected.

Anatomists divide the small intestine into duodenum, jejunum, ileum—a division of but little importance in physiology.

§ 68. *Liver and Pancreas.*—The alimentary matters which have passed into the small intestine mingle with the fluids secreted by its walls and with two peculiar liquids secreted by the liver and pancreas (the bile and the pancreatic juice), two glandular organs situated in the immediate neighbourhood of the intestine.

The liver (Fig. 32), the organ which secretes the bile, is the largest viscus in the body. It is situated in the upper part of the abdomen, mostly on the right side, and extends as far as the lower edge of the ribs. Its upper surface is convex, the lower concave and irregular; its colour red-brown; its substance soft, yet compact; and when torn it appears to be formed of an agglomeration of small solid granulations, in which bloodvessels abound and from which arise the excretory canals of the bile.

These excretory canals unite so as to form smaller and larger trunks successively, until they terminate in a single trunk, which, after a certain course, terminates in the duodenum a short way from the pyloric orifice of the stomach. The hepatic tube thus described communicates by a short tube with the gall-bladder, which is maintained full of bile by means of the cystic duct.

In the lower animals the liver is often replaced by an agglomeration of small tubes terminating in cul de sacs, and inserted by their open mouths into the branches of an excretory canal (as in the crabs and lobsters), or by simple but long vessels, as in insects. Finally, in beings of a very simple organization, the liver is either wanting or replaced by a glandular tissue surrounding a portion of the intestine; nevertheless, it is one of the organs found most constantly to exist in the animal kingdom.

§ 69. The *bile* is a viscous liquid, greenish in colour, thready, and extremely bitter. It is always alkaline, and has a strong analogy with soap.

Chemical analysis shows it to be composed of a salt formed of soda united to a fatty acid of a peculiar nature, cholesterine, a colouring principle, a little of the oleate or margarate of soda, mucus, and water. But the bile has other uses, furnishing peculiar substances to the blood.

§ 70. The *pancreatic juice* strongly resembles saliva, physically and chemically; but, in addition, it rapidly unites into an emulsion with fatty bodies; the pancreatic gland,* which forms it, resembles the salivary glands in structure. In man it is a granular mass, divided into a great number of lobes and lobules, firm in consistence, and of a greyish colour, slightly reddish, situated transversely between the stomach and vertebral column (Fig. 32). From each of the granulations there arises a fine duct, and all these reunite to form a canal which opens into the duodenum close to the entrance of the bile duct.

§ 71. *Formation of the Chyle.*—The chyme formed in the stomach enters the intestine by the pyloric orifice of this viscus, and passes through the intestine by its peristaltic motion. During this passage it mingles with the bile, pancreatic juice, and other secretions from the mucous membrane of the intestine, and gradually changes its properties; it becomes bitter, yellowish, less and less acid, then alkaline;

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* From πᾶν, *all*, and κρέας, *flesh*.

the amylaceous and fatty bodies which had resisted the action of the gastric juice are now acted on by the bile and pancreatic juice; and various gases are disengaged from the alimentary mass distending the intestine. These gases are chiefly carbonic acid gas and hydrogen; sometimes nitrogen. Finally, the more fluid parts of the chymous mass are absorbed by the lacteals, which become rarer and rarer towards the lower portion of the small intestine, until they are no longer to be found, and the mass formed by the remains of the chyme, by the bile, and other humours already mentioned, acquires in this portion of the tube more consistence, assumes a brown colour, and thus passes into the large intestine.

Expulsion of the Residue left after Digestion.

§ 72. The alimentary matters which do not admit of digestion require to be expelled from the body. For this purpose they are collected into the large intestine.

The Large Intestine (Fig. 32) is continuous with the small, and in most mammals is easily distinguished from it by its irregular cellular aspect. Anatomists divide it into *cæcum*, *colon*, and *rectum*. The cæcum,* situated in the right iliac region, is prolonged into a cul de sac, beyond the point of insertion of the small intestine. At its lower extremity it communicates with a small tube, the appendix vermiformis, which may be considered as a prolongation of the cæcum. A very perfect valve, formed of folds, and situated internally at the junction of the small intestine with the large, is placed so as to prevent or impede the return of whatever has passed from the small into the larger bowel.

The colon is a continuation of the cæcum. It traverses the abdomen immediately beneath the stomach, gains the left side, and, descending to the edge of the pelvis, is continuous with the rectum. This latter terminates at the anus.

§ 73. The residue of the food passing from the cæcum and colon to the rectum, remains there for a certain time. The matter has now acquired considerable consistence and a peculiar odour. Gases are developed which differ from those generated in the small intestine; they are the carbonated hydrogen, and a little sulphuretted hydrogen.

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* The cæcum (*cæcus*, blind) forms a cul de sac at the commencement of the large intestine.

Fleshy fibres, forming a sphincter, constantly in action, surround the aperture of the bowel, and thus prevent the escape of its contents, until the moment arrives for its evacuation. This is effected mainly by the muscular action of the bowel itself, assisted occasionally by the diaphragm and levatores ani muscles.

§ 74. *Theory of Digestion.*—The object of digestion is to fit the food for absorption by the lacteals. A portion of the alimentary mass being soluble in water, is of consequence directly dissolved by the saliva, the gastric juice, and the water swallowed as part of our food, without the intervention of any special active principle. The animal *diastase* contained in the saliva possesses the property of transforming fecula into glucose, and thus determines the solubility of a portion of the amylaceous matters introduced into the stomach. The pepsin contained in the gastric juice acts in an analogous manner upon the fibrin, albumen, &c., and liquefies these substances in the cavity of the stomach. The fecula which may have resisted the action of these agents, and has reached the intestine untouched, there meets with the pancreatic fluid, whose action is analogous to that of the salivary secretions, and thus the solution of the amylaceous portions of the food is completed. Finally, the fatty matters, which also have escaped the action of the saliva and gastric juice, are formed into emulsions by the action of the pancreatic secretion, and sometimes by the aid of the alkali contained in the bile; and just as these various solutions go on, the product is taken up by the absorbents in connexion with the walls of the stomach and intestine. Certain of the substances thus dissolved undergo modifications in their chemical nature. Thus the sugar of the sugar-cane is changed into glucose; but the most important and most general of the phenomena connected with digestion is the liquefaction of the alimentary matters.

Absorption of the Products of Digestion.

§ 75. The nutritive matter thus extracted from the aliment has now to pass into the mass of blood, which fluid it is destined to renovate.

Some of the liquids and soluble matters introduced into the stomach and intestine are absorbed directly by the veins which abound in the walls of these organs; but the greater part of the fibrin and fatty matters which form the chyle follows another route, and penetrates another system of vessels, by which it reaches the veins, but in an indirect way. These vessels, called indifferently lacteals,* or chyliferous vessels, form a portion of the absorbent or lymphatic system of vessels. (See § 34.) They originate in the villosities of the mucous membrane of the small intestine, and unite into branches or single vessels, which are placed between the two folds of the mesentery. In their course towards the thoracic duct, these lacteals pass through the ganglions called mesenteric (Fig. 35). Again assuming the form of single vessels on emerging from these ganglions, they proceed to the thoracic duct, in which they terminate. By means of this duct, the

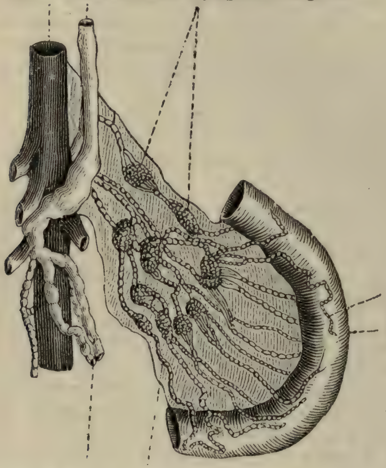
Aorta.
Thoracic Canal.
Lymphatic Ganglions.
Radicles of the chyliferous vessels.
Intestine.
Lymphatic Vessels.
Mesentery.

Fig. 35.—Chyliferous Vessels.

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* From the milk-like appearance of the chyle which they contain. The lacteals proceeding from the intestine to the lymphatic glands or ganglions are called *vasa afferentia,* and those from the glands to the thoracic duct *vasa efferentia.*

chyle thus formed is conveyed into the left subclavian vein (Fig. 3).

§ 76. When an animal has been kept without food for some time, these vessels are nearly empty; but when digestion is going on rapidly they become filled with chyle, the colour of which is white, like milk; and hence the name of lacteals given to them by their discoverers.

The absorption of the chyle seems to take place chiefly by means of the villosities; for so soon as this phenomenon commences, they become swollen, like sponges filled with milk by imbibition. From these the chyle passes into the lymphatic (*lacteal*) vessels, by a process as yet unknown; and after traversing the mesenteric glands, proceeds by other lacteals from these glands to the thoracic duct. The cause of this upward and onward movement of the chyle towards the veins is not well known.

§ 77. *Chyle.*—This liquid varies in appearance according to the animal and the kind of food which has been used. In man and in most mammals it is of a milky-white colour, of a peculiar odour and brinish alkaline taste. Examined by the microscope, it seems composed of a serous liquid, holding in suspension fatty drops and circular globules. Chyle formed from food not including fatty matters is much less opaque than that having in its composition oil and fat. In birds, the chyle is almost always transparent.

Taken from the lacteals near their origin in the intestines, the chyle is found to be composed mostly of albuminous matters; but examined in the thoracic duct, near its junction with the subclavian vein, it is found to contain fibrin, increasing in quantity the nearer to its passage into the venous blood. On the presence of this substance depends its property of spontaneous coagulation, like the blood. It now becomes of a light rose-colour, and reddens slightly on exposure to the air. In brief, it more and more resembles the blood, with which it finally mingles in the left subclavian vein.

We have traced the elaborated nutritive matter to the blood. This fluid must now engage our attention, also the manner in which it is distributed to all parts of the body.

OF THE BLOOD.

§ 78. In animals of the simplest structure, all the liquids of the animal economy resemble each other. It seems, indeed, to be only water charged with a certain amount of organic particles; but in animals higher in the scale of being, the humours cease to be of the same nature, and there is one, distinct from all the others, destined to nourish the body: this fluid is the blood. It not only nourishes the body, but is the source whence are drawn all the secretions, such as the saliva, urine, bile, and tears.

§ 79. In mammals, birds, reptiles, fishes, and in most animals of the class annelides, the blood is red. But in the greater number of the lower animals the blood presents various hues and density, being often thin or watery, and slightly yellow or green, rose-coloured or lilac. It is difficult, therefore, to be seen, and for a long time these animals were called bloodless or exsanguineous.

Those animals with white blood are very numerous; all insects, for example.* The crustacea of all sorts have only white or pale-coloured blood; and in this category may be placed all the mollusca, zoophytes, and intestinal worms.

§ 80. By the use of the microscope we discover that the blood of a red-blooded animal is composed of a yellowish transparent liquid, called serum, and of a number of small solid corpuscles which float in the serum, called blood globules.

§ 81. *Globules of the Blood.*—Before birth, the globules have dimensions and even a form different from what they afterwards acquire. Thus in the chick the globules of the blood are at first circular; and it is only at a more advanced period of incubation that the globules assume an elliptic form. After birth the globules never vary.

In all animals of the same species the globules have the same form and nearly the same dimensions. It is not so with different species. It has been observed also that in animals of the same class the blood globules resemble each other, but differ from those of other classes. In the first, they have nearly all the same form; but in those of a different class, they may vary not only in dimensions but even in form.

Thus, in man (Fig. 36) and in most mammals the globules of the blood are circular. In the camel and lama, however, they are elliptic. In birds, reptiles, batrachia, and fishes, they are elliptic (Fig. 37.)

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* The red-coloured liquid which appears when the head of these insects is crushed is not blood, but comes from the eyes.

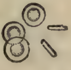

Fig. 36.*

The corpuscles are always microscopic; and in man, and in mammals generally, they are extremely small. In man, the dog, rabbit, and some others, their diameter is from the three-thousandth to the four-thousandth part of an inch.

In birds, the globules are larger than in mammals. In the reptiles and batrachia they are still larger. In the proteus they attain their maximum.

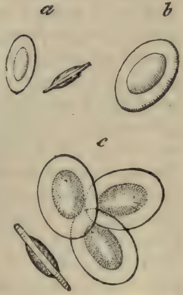

Fig. 37.†

Finally, in fishes, the blood globules are intermediate between those of birds and the batrachia.

Moreover, the blood globules are always flattened, and present a central spot or nucleus, surrounded with a rim or border. Their structure is extremely difficult to be clearly made out; but when seen to most advantage, they seem to be composed of a central nucleus and an envelope resembling a bladder. This envelope being depressed, gives to the globule the appearance of a disc swollen in the middle. It is of a reddish colour, and seems formed of a substance resembling jelly, but very elastic. The central nucleus is of a spheroidal form, and is not coloured. In mammals the nucleus is not distinct, and the central portion is depressed; but analogy induces us to suppose that, as in other animals, it is also present in man.

Other globules, spherical and colourless, exist in the blood, resembling greatly those observed in the chyle; from being mingled with the red globules they are not readily observed.

§ 82. In the white blood of the invertebrate kingdom, globules are also found, but different from those described; the size varies much in the same individual, and their surface has a raspberry appearance; their form is generally spherical, but neither a central nucleus nor external envelope is to be seen.

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* Globules of the human blood, magnified nearly 400 times (in diameter).

† Elliptic globules of the blood in birds, batrachia, and fishes;—*a*, globules of the blood in the domestic fowl, seen in profile;—*b*, globules of the blood in the frog;—*c*, globules of the blood in a fish of the shark kind (equally magnified).

§ 83. *Composition of the Blood.*—The composition of the blood is very complex. In the higher animals we find water, albumen, fibrin, a colouring matter containing iron, a yellow colouring matter, several fatty substances, as cholesterine, cerebrine (a substance containing phosphorus); many salts, as chloride of sodium or sea salt, sulphate of potass, carbonate of soda, hydrochlorate of potass, hydrochlorate of ammonia, the carbonates of lime and magnesia, with phosphates of soda, lime, and magnesia; the lactates of soda, the alkaline salts formed by the fatty acids; finally, free carbonic acid, nitrogen, and oxygen. But this complexity, great though it be, is yet below the reality, for there certainly exist other substances in the blood which chemistry cannot demonstrate, by reason, probably, of our imperfect means of analysis. By arresting, for example, the secretion of the urine from the blood, various matters will then be found mixed with the blood which could not be previously detected, but which are presumed to have been present under the same or other unknown forms.

The substances enumerated as entering into the composition of the blood compose nearly all the parts of the animal economy: the albumen forms the basis of many tissues, the fibrin is the constituent part of the muscles, and the salts enter into the composition of the bones and of many humours; and from the whole of the facts known, it may be safely concluded that the materials destined to become flesh, bile, urine, &c., already exist in the blood, the organs which are to appropriate them merely drawing them from the blood, but not forming them: and thus there exists some reason for calling the blood *liquid flesh.*

§ 84. The proportions in which these constituent parts of the blood exist vary much in different animals; and as regards the solid and liquid elements, they may differ in the same individual at different times. In man the globules are more numerous, and the watery part less than in woman; temperament also exercises some influence in this respect. In 100 parts of the blood in man, we find 79 parts of water, 19 of albumen, 1 part of salts, with some traces only of fibrin and colouring matter. In birds, the proportion of water in the blood is less; but in the batrachia and in fishes the amount is greater. In the frog, for example, there are 88 parts of water in 100 of the blood.

Analogous differences are observed in comparing the relative qualities of the serum and globules of the blood in different animals; while—as we shall subsequently see—there exists a remarkable relation between the amount of the globules and the animal heat. Birds, of all animals, have the blood richest in red globules, and in them the animal heat is greatest. Mammals, less warm than birds, have from 7 to 12 per cent., whilst in reptiles and fishes, the proportion does not exceed 5 or 6 per cent. of the whole weight of the blood.

§ 85. *Coagulation of the Blood.*—In its ordinary condition the blood is always fluid: withdrawn from the vessels of the living animal, and left for a time to itself, it separates into two portions, a semi-solid mass and a liquid portion, in which the mass floats; the solid part is called the *clot.*

This phenomenon (the formation of the clot) is due to the presence of fibrin in the blood; it is held in solution in the serum during life, but when this loses its influence over it, it solidifies, inclosing with it the red globules, and thus forming the red gelatinous mass called the clot. The simple experiment of beating up the blood with little rods as it flows from the veins, and thus removing the fibrin, which adheres to the rods, proves that the coagulability of the blood depends on the presence of this substance.

Another experiment equally simple shows that the fibrin is contained in the serum, and not in the red globules, as was long supposed. Throw on a filter the blood of a frog; all the serum may be made to pass, and the globules retained; in the serum thus separated from the globules a clot is formed, which, however, is colourless.

§ 86. *Use of the Blood.*—The blood is the special agent of nutrition, and the general restorer of what is lost.

§ 87. But in addition, it is proved, by the simple experiments of bloodletting and of transfusion, to form an essential stimulus for the performance of the functions of life. By severe bloodletting or loss of blood we become enfeebled and seemingly dead; but if, before this happens, the blood of another animal be transfused into the veins of the suffering individual, the vitality is restored. The importance of the globules is also proved by the same experiment, for if simple serum be so transfused, death takes place.

The fibrin of the blood also plays an important part, for M. Magendie has shown that when blood deprived of its fibrin is injected into the veins of a dog, the animal dies with symptoms resembling those of putrid fevers.

§ 88. The influence of the blood over nutrition may also be readily demonstrated. Withdraw the blood more or less from any organ, and it gradually wastes away in proportion to the quantity withdrawn; on the contrary, the greater size of the muscles in those who employ them actively, and hence draw to them a larger amount of blood, is well known.

§ 89. The blood, by thus acting on the organs, loses its nourishing properties. It reaches them of a bright vermilion colour; as it leaves them it is dark and sombre-coloured, and has lost its qualities of maintaining life. But the blood thus altered has its vital properties restored by being exposed to the atmosphere. This important function is called Respiration. The blood which has been exposed to the air is called *arterial:* that which has already acted on the organs is called *venous;* the latter is chiefly distinguished by its dark colour.

CIRCULATION OF THE BLOOD.

§ 90. The circulation of the blood in man and mammals was discovered by Harvey in 1619.

In order to nourish all the parts of the body, it is necessary that the blood should be conveyed to these parts by means of vessels; and that, to circulate in these vessels, there should be a power or organ equal to the production of such a movement. But it is also necessary, in the higher animals, that the blood should be passed through the respiratory organs, in order to be exposed to the action of the air; hence the necessity of a circulation of the blood through the lungs, as well as through the body, and hence both a pulmonary and a systemic circulation.

§ 91. *Apparatus of the Circulation.*—In certain of the lower animals, the air penetrates into the tissues through pores situated on the surface of the body; but in all the higher animals, and in many of the lower, there exists a very complex apparatus for the circulation of the blood: 1. A system of tubes or canals, destined to convey the blood into the various parts of the body. 2. An organ destined to put this fluid in motion. In other words, *bloodvessels* and a *heart.*

The heart is the centre of the circulatory apparatus: it is a pouch or bag, more or less complex, into which the blood is returned by the veins, and from which it passes to the body, thus constantly circulating. It is, in fact, a forcing-pump placed at the centre of the circulatory system.

Most animals, from man to the spider, have a heart; but the arrangement differs in the various classes of animals.

The bloodvessels are of two kinds: 1. Arteries, which convey the aerated blood into the various parts of the body. 2. Veins, which re-convey the blood to the heart from the body. The arteries, proceeding from the heart, divide and subdivide in their course as they proceed, until they become exceedingly small: the veins follow a different course; they commence by extremely fine roots, and collect into large branches and trunks as they proceed towards the heart. In the arteries, the motion of the blood is from the heart; and in the veins, towards the heart. The arteries terminate, and the veins commence, in a fine network of vessels formed by both; the vessels composing this network are called capillary. The heart being thus placed between the termination of the veins and the commencement of the arteries, the movement of the blood in man and higher animals is a complete circle, the blood always returning to the point from which it started; hence it has been called the *circulation of the blood.*

In all animals in which the respiration is performed by a special organ, the blood is sent to it from the heart, and retires from it by a special system of canals; the circulation thus established is called the respiratory or the *lesser circulation*, whilst that through the body is called the *greater*. We shall consider, first, the circulation in man, and this will serve as a standard of comparison with others.

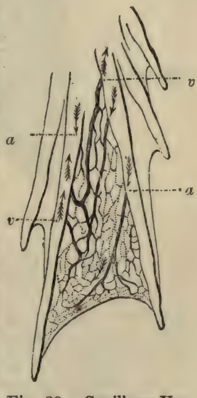

Fig. 38.—Capillary Vessels in the Foot of the Frog.*

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* *a*, arteries. *v*, veins. The arrows point out the direction of the circulating fluids.

Description of the Circulation of the Blood in the Higher Animals.

§ 92. *The Heart.*—In man, and all animals similarly organized, the heart is lodged between the lungs and in the cavity of the chest called by anatomists the *thorax* (Figs. 5 and 58): its lower extremity is directed somewhat obliquely towards the left side and forwards; and its upper extremity, from which spring the great vessels, is fixed to the neighbouring parts, nearly in the mesial plane of the body. Throughout the rest of its extent the heart is free, but is surrounded by a fibro-serous membrane, called the pericardium, which not merely forms a shut sac for containing the heart, but gives to its surface a smooth covering, by which it

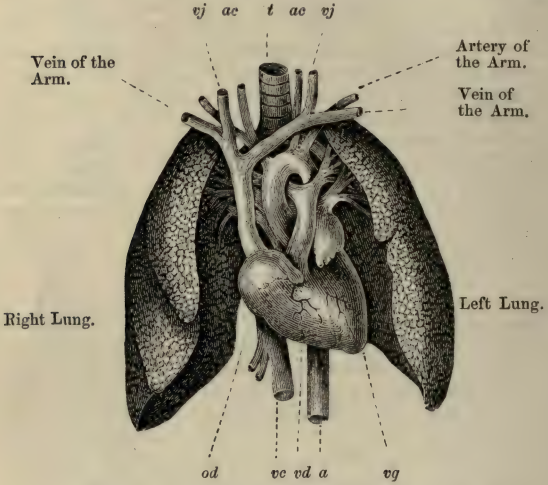

Fig. 39.—Lungs, Heart, and Principal Vessels in Man.*

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* *od*, *vd*, right auricle and ventricle;—*vg*, left ventricle;—*a*, aorta;—*ac*, carotid arteries;—*vc*, vena cava inferior;—*vj*, jugular veins;—*t*, trachea.

is enabled to move freely in the cavity so formed; an aqueous fluid, the liquor pericardii, lubricates it at all times.*

The general form of the heart is that of a cone or irregular pyramid reversed; it is almost wholly flesh, hollow, and in man about the size of the closed hand or fist. In all the mammalia and in birds the heart is composed of four cavities,—namely, a right auricle and ventricle, and a left auricle and ventricle; these are separated from each other by a vertical septum (Fig. 40), cutting off all communication between those of the right side and those of the left.

Each auricle communicates only with its corresponding ventricle (Figs. 40 and 42).

The two ventricles occupy the lower part of the heart, and do not communicate with each other, but with their corresponding auricles. The orifices are called the auriculoventricular orifices, right and left. The left cavities of the heart contain arterial blood; the right, venous. The auricles, having to propel the blood only into the ventricles, are not so

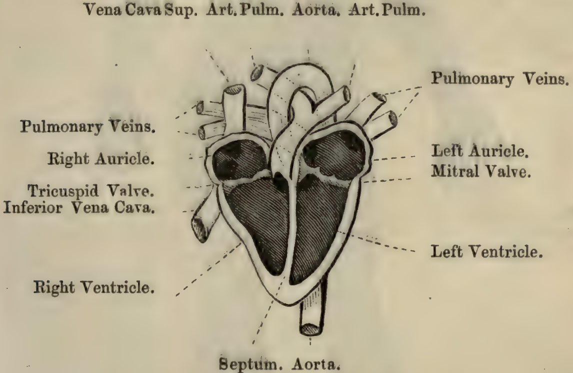
Vena Cava Sup.
Art. Pulm.
Aorta.
Art. Pulm.
Pulmonary Veins.
Pulmonary Veins.
Right Auricle.
Left Auricle.
Mitral Valve.
Tricuspid Valve.
Inferior Vena Cava.
Left Ventricle.
Right Ventricle.
Septum.
Aorta.

Fig. 40.—Theoretical Section of the Heart in Man.

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* The pericardium is a fibro-serous membrane. By investing the surface of the organs, as well as the walls of the cavities containing them, the serous membranes provide for the friction of such organs as are in constant motion, as the brain, heart, lungs, and abdominal viscera: analogous membranes are found in the articulations.

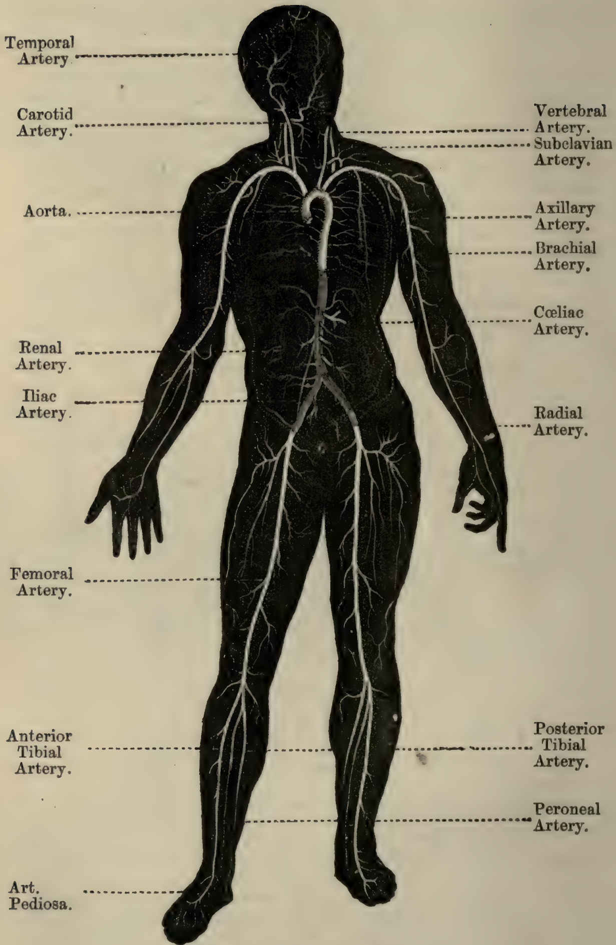
Temporal Artery
Carotid Artery.
Aorta.
Renal Artery.
Iliac Artery.
Femoral Artery.
Anterior Tibial Artery.
Art. Pediosa.
Vertebral Artery.
Subclavian Artery.
Axillary Artery.
Brachial Artery.
Cœliac Artery.
Radial Artery.
Posterior Tibial Artery.
Peroneal Artery.

Fig. 41.—Arterial System in Man.

fleshy in their walls as the ventricles; and of these the left is much the stronger, as it has to drive the blood through the whole body excepting the lungs; whilst the right ventricle merely propels it through the lungs.

§ 93. *The Bloodvessels.*—These vessels are divided into arteries and veins. The walls of these tubes are formed of membranes or tissues. In the arteries there are three tissues: the inner, continuous with the inner membrane of the heart, resembles the serous membranes; the middle tissue is fibrous and elastic; the outer tissue, cellular and also elastic. The fibres of the middle tissue are disposed circularly. In the veins, the middle tissue is not so distinct, being composed merely of fibres, irregularly disposed; these are soft, extensible, and longitudinal. Thus the physical properties of the veins and arteries differ widely. The veins have thin walls, which collapse when the vessels are empty; and they heal easily when wounded. On the contrary, the arteries when cut across, remain open, and when wounded do not heal so perfectly; in order to close, they must be obliterated, either by pressure or by the use of the ligature.

§ 94. *Arterial System.*—From a single artery, called the aorta, springing from the left ventricle of the heart, all the arteries of the body arise. It must, however, be borne in mind that the artery called the pulmonary springs from the right ventricle, and carries the venous blood to the lungs. The accompaning figure (41) explains perfectly the course of this great artery (the aorta), from its commencement in the heart to its termination; also of all the great branches which arise from it.

§ 95. *Venous System.*—The veins originating in the capillary vessels, in which the arteries terminate, follow pretty nearly the course of the arteries; but they are more numerous and more superficial. Many are situated immediately beneath the skin, imbedded in the superficial fascia of the body. Others follow the course of the arteries, to terminate however at length in two large trunks, which empty themselves into the right auricle of the heart (Fig. 39).*

The veins of the intestines present this remarkable anomaly —that they unite into a single trunk, which, instead of joining the venous system, directly proceeds towards the liver, and is ramified through that organ after the manner of an artery;

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* A smaller vein, called coronary, returns the blood which has circulated in the walls of the heart into the same cavity.—R. K.

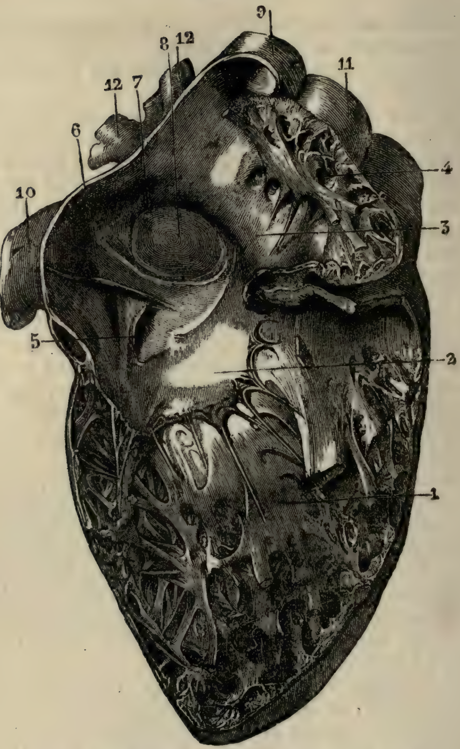

Fig. 42.—Vertical Section of the Human Heart.*

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* Venous cavities of the heart.—1. Interior of the right ventricle, showing the fleshy columns strengthening its walls. 2. Portion of the tricuspid valve, which, on rising up during the contraction of the ventricle, partially closes the aperture leading into the auricle; the tendinous cords attached to the fine edges of the valve prevent it returning too far towards the auricle, these tendons being attached by their other extremities to the fleshy columns and fleshy walls of the ventricle. 3. Cavity of the right auricle. 4. Fleshy columns strengthening the walls of the cavity. 5. Orifice of the great coronary vein returning the blood from the tissue of the heart itself to the cavity of the auricle. 7 & 8. Fossa ovalis, in the bottom of which may be seen the remains of the opening by which, in the fœtus, the two auricles communicated directly with each other. 9. Orifice of the vena cava superior. 10. Trunk of the inferior vena cava. 11. The great artery called aorta. 12, 12. The pulmonary veins.

but the veins which leave the liver unite with the vena cava inferior before that vessel enters the right auricle.

§ 96. *Lesser Circulation.*—The venous blood conveyed into the right auricle by the two cavæ and by the coronary vein, passes from this auricle into the right ventricle, and by its action is driven along the pulmonary artery into the lungs (Figs. 39 and 40). The latter vessel is called an artery, although it carries only venous blood. In the right lung it divides into three branches, and in the left into two; thus corresponding as it were with the number of the lobes of each lung.

§ 97. The pulmonary veins, as they are called, carry back from the lungs the whole of the blood which has been conveyed to these organs by the pulmonary artery. In the capillary system of these vessels, the blood has been in the mean time aerated, revivified, and arterialized, and fitted once more to perform its part in renovating the organs and maintaining life. From the left auricle, in which the four pulmonary veins terminate, the blood passes into the left ventricle, and by its powerful action is driven through the aorta and its branches into all parts of the body, to return once more by the veins to the right auricle of the heart. Thus is completed the double circulation in man, mammals, and birds.

Mechanism of the Circulation.

§ 98. *Movements of the Heart.*—The cavities of the heart being muscular, contract and dilate: the dilatation is called the *diastole*,[*] the contraction, *systole*.[†] As the auricles of the heart dilate, they receive the blood, the right that of the body, the left, that which is returning from the lungs; when full, they contract on their contents, forcing the blood into the ventricles; these in their turn suffer dilatation as they fill, and, contracting suddenly, force the blood, the right into the pulmonary artery, the left into the aorta. These movements of the heart continue whilst life endures, and are much influenced by various circumstances, such as exercise, disease, &c. The number of these contractions, usually felt in the radial artery at the wrist, varies with years; they are most frequent in the young, and average about seventy in the adult, at noon. They are affected by every change in the position of the body.

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[*] From διαστέλλω, I dilate.

[†] From συστελλω, I enclose.

§ 99. *Passage of the Blood into the Cavities of the Heart.*—This has been already described, but may be thus again briefly adverted to. The blood having an arterial character, returns from the lungs into the left auricle. This auricle communicates with the left ventricle by an opening called the left auriculo-ventricular aperture, through which the blood flows from the auricle into the ventricle. In this passage is placed a valve, called mitral, permitting the blood to pass, but not to return. The arterial blood now collected in the ventricle is acted on by this fleshy cavity, and forced into the aorta; at the entrance of the aorta are three valves,

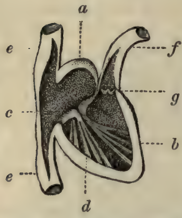

Fig. 43.—Section of the Heart.*

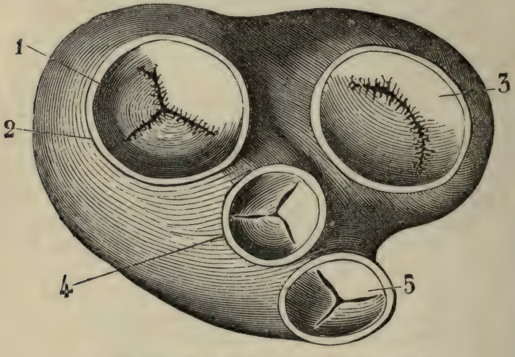

Fig. 44.—Valvules of the Heart and Arteries.†

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[*] Theoretic section of the heart, to show the mechanism of the play of the valves: *a*, auricle receiving the veins *e e*;—*b*, ventricle separated from the auricle by the valvules *c*;—*d*, fleshy bridles or stays of these valvules;—*f*, artery springing from the ventricle;—*g*, valvules situated at the entrance of the artery.

[†] Upper surface of the heart, the auricles having been removed.—1, auriculo-ventricular orifice, obliterated by the tricuspid valve; 2, fibrous ring surrounding the orifice; 3, left auriculo-ventricular orifice, surrounded by a ring, and closed by the mitral valve; 4, orifice leading into the aorta from the left ventricle, closed by the semilunar valves; 5, orifice leading into the pulmonary artery from the right ventricle, also provided with three semilunar valves.

the semilunar, permitting the blood to flow freely into the artery but not to return into the ventricle; distributed by the aorta and its branches to every part of the body and to the fleshy walls of the heart itself, the blood is taken up by the venous capillaries, and returned to the right auricle by the two venæ cavæ and coronary vein; collected in this auricle it is strictly venous blood, but has already received the product of digestion. From this auricle, and by its action, the blood is driven through the right auriculo-ventricular orifice into the right ventricle; the tricuspid valve permits it to pass into the ventricle, but not to return. By the action of this ventricle the blood is forced into the pulmonary artery, and by it to the lungs, thence to be returned (aerated) to the left auricle by means of the pulmonary veins. At the entrance of the pulmonary artery there are, as in the aorta, three semilunar valves, permitting the blood to pass freely into the artery, but not to return. From the mechanism alone of the valves alluded to, the circulation of the blood might easily have been foretold.

§ 100. *Course of the Blood in the Arteries.*—Contrary to what might have been expected, the blood flows in the arteries in a continued stream, and with considerable force. This is due chiefly to the action of the heart itself, but partly also to the elasticity of the arteries themselves. The influence of the elasticity of the walls of the arteries on the passage of the blood is proved by placing two ligatures, at a certain distance from each other, on a large artery in a living animal, and then puncturing the vessel at any point between the ligatures. The blood contained in this insulated portion of the vessel is thrown out of it with considerable force. Thus, by means of the elasticity of the arteries, the jet of blood, or the intermittent movement impressed on the blood by the action of the heart, is transformed into a continuous flow or stream. In the capillaries, it is presumed that the blood flows on by this means alone; but some suppose them to be muscular.

§ 101. Thus the left cavities of the heart perform the function of a double forcing-pump (Fig. 45), so arranged, that the two pistons alternate in their movements; thus the liquid chased from the first body of the pump (*a*) is introduced into the second (*b*), without being able to retrace its steps, and is thrown by this second pump into the canal (*f*) representing the arterial system.

§ 102. When the finger is gently pressed against an artery resting on a firm surface, as a bone, an impulse or jet is felt to strike the finger regularly. This is due to the action of the left ventricle on the fluid, and is a phenomenon produced in a great measure by the pressure exercised by the finger. It is called the pulse, and is most usually felt at the wrist (Fig. 41), the radial artery being favourably placed in this respect.

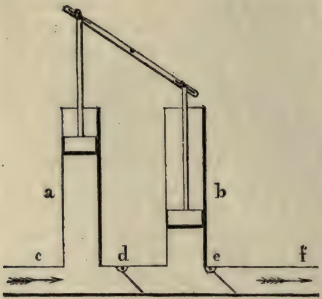

Fig. 45.*

§ 103. The blood does not reach all the organs with the same swiftness. Distance from the heart is one cause: but it is not the only one. The arteries run mostly in a tortuous manner, and this causes, as is well known, a retardation of the fluid circulating. By a vast increase of minute branches, the blood is spread into many channels; hence arises another cause of retardation as regards the arteries. Finally, Nature, all-foreseeing, provides, by numerous *anastomoses* or junctions of the vessels, for any accidental stoppage or obliteration of the larger or smaller trunks.

§ 104. *Course of the Venous Blood.*—The blood passes, by means of the capillaries, from the arteries into the veins. The impulsion it first receives from the heart determines its course in the veins. This is proved experimentally, by placing a ligature on the artery supplying certain veins, and thus cutting off the action of the heart; the hæmorrhage from a punctured vein will cease, even although the vein be full of blood, and will return when the action of the heart is allowed to influence it, by removing the ligature from the artery.

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* *a*, body of the pump representing the auricle, and receiving the liquid by the canal *c*; *b*, body of the pump representing the ventricle; *d*, canal of communication, representing the auriculo-ventricular orifice, furnished with a sucker permitting the fluid to pass from *a* to *b*, but opposing its return; *e*, the sucker or valve, situated at the opposite orifice of the pump *b*, representing the semilunar valves of the aorta, and having the same action as the preceding valve or sucker; *f*, canal, representing the aorta.

But there are other circumstances influencing the motion of the blood in the veins. These vessels, and more especially those of the limbs, are provided with valves (*b*), permitting the blood to flow towards the heart, but preventing its reflux toward the capillaries. *Every intermittent compression of these vessels contributes to the return of the blood to the heart.*

§ 105. The dilatation of the chest caused by respiration facilitates the return of the blood towards the heart. By expiration the movement of the blood in the veins is momentarily interrupted; and the double motion observed in the brain, when a portion of the skull-cap has been removed, is due partly to respiration, partly to the resistance which the base of the brain offers to the dilatation of the arteries situated between the base and the skull.

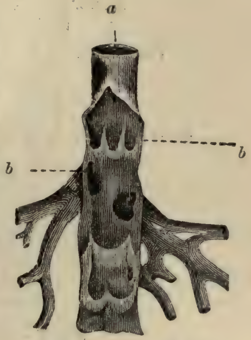

Fig. 46.—Vein, laid open.

§ 106. The course of the venous blood, and the mechanism of the cavities through which it passes from the veins to the lungs, by means of the right auricle, ventricle, and pulmonary artery, has been already described. In the capillaries of the pulmonary artery the blood is changed into arterial, and so returns by means of the pulmonary veins to the left auricle of the heart.

Course of the Blood in Different Animals.

§ 107. *Mammals and Birds.*—The circulation in these two classes of animals is the same (47). It is what is called a double circulation, the blood passing through two sets of capillaries—one belonging to the body, the other to the lungs; the former serving for the nutrition of the body, the latter for the aeration of the blood. This kind of circulation has also been called complete, which means that the whole of the blood circulates through the lungs before being restored to the body.

Before birth there exists an opening between the right and

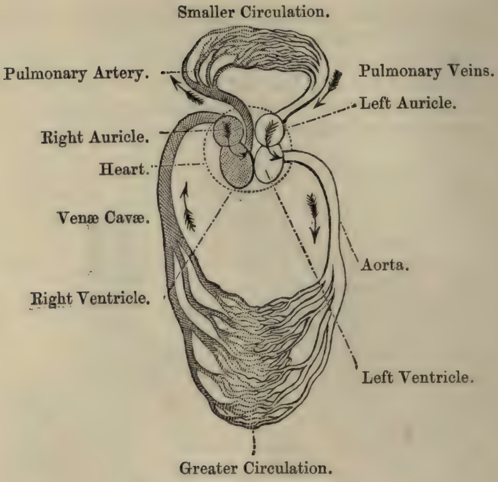
Smaller Circulation.
Pulmonary Artery.
Pulmonary Veins.
Left Auricle.
Right Auricle.
Heart.
Venæ Cavæ.
Aorta.
Right Ventricle.
Left Ventricle.
Greater Circulation.

Fig. 47.—Mammals and Birds.

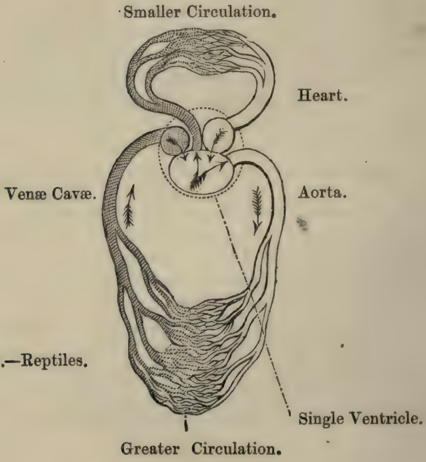
Smaller Circulation.
Heart.
Venæ Cavæ.
Aorta.
Single Ventricle.
Greater Circulation.

Fig. 48.—Reptiles.

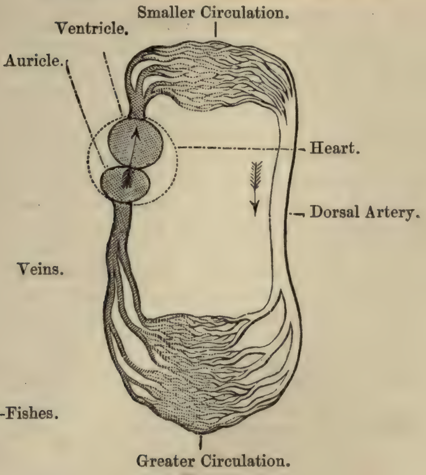
Smaller Circulation.
Ventricle.
Auricle.
Heart.
Dorsal Artery.
Veins.
Greater Circulation.

Fig. 49.—Fishes.

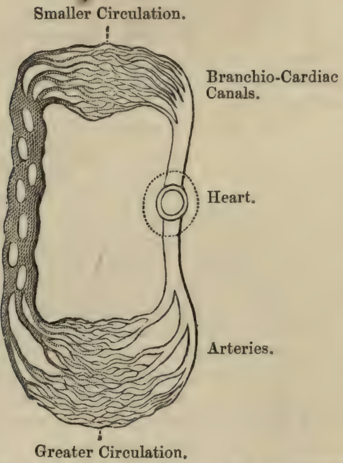
Smaller Circulation.
Branchio-Cardiac Canals.
Heart.
Arteries.
Greater Circulation.

Fig. 50.—Crustacea.*

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* In all these figures the shaded parts represent the veins; the parts simply traced represent the arteries; the dotted circle represents the heart. Finally, the arrows point out the direction of the sanguine current, which is the same in all the figures.

left auricles, by which the blood conveyed to the heart by the vena cava inferior passes directly into the left auricle. This blood comes mostly from the placenta. The pulmonary artery also, before birth, divides into three branches instead of two, as in the adult; the centre branch passes into the aorta. This peculiar mechanism connected with fœtal life disappears soon after birth, leaving merely traces of its existence.

§ 108. *Reptiles.*—In this class the circulation is not complete. The heart has only three cavities instead of four, as in mammals and birds—namely, two auricles and one ventricle (Fig. 48); the venous blood coming from the various parts of the body is poured by the right auricle into the single ventricle, which receives also the arterial blood from the left auricle—a portion of this mixed blood is returned to the lungs, and the rest proceeds to nourish the body. The circulation in reptiles resembles somewhat that of the fœtus of the higher classes of animals. From the heart (ventricle) there proceed two arteries or *aortæ*, which, after having each furnished a cross or arch, one to the right the other to the left, reunite to form a single trunk (51). In some reptiles, the crocodile for example, the circulation is somewhat different. We shall describe it when speaking of these animals.

§ 109. *Fishes.*—In Fishes the circulation may be said to be still more simplified. The heart has only one ventricle and one auricle. This auricle receives only venous blood returned to it from all parts of the body. From this cavity it passes into the ventricle, from which springs a single artery, having at its origin a strong arterial bulb (Fig. 49). Through this single artery it is conveyed first to the gills, and the vessels returning from these unite to form a single dorsal artery (the aorta), by whose branches the blood is conveyed to all parts of the body, returning by the veins to the auricle from which it started. Nevertheless, the circulation is here complete, since all the blood is *aerated* before its employment in nourishing the body (Fig. 49, p. 63).

§ 110. *Mollusca.* In most of the mollusca the circulation resembles that of fishes, but the heart is *aortic* and not pulmonary—that is to say, it is placed in the course of the blood proceeding from the respiratory apparatus to the body, and the venous system is more or less incomplete. The heart in these animals is composed usually of a ventricle (Fig. 53 *h*), whence spring the arteries (*i*), and of one or two auricles in communication with the vessels (*o*), which carry the arterial blood from the respiratory apparatus (*d*), which this liquid reaches by venous canals more or less complete (*n*). This is the case in snails, oysters, and all acephala, as well as the class gasteropoda; but sometimes there exist no auricles, and a kind of venous hearts is found altogether distinct from the aortic ventricle, and situated at the base of the respiratory organs; this takes place in the sepia, and other cephalopoda. However it may be, the arterial blood in all these animals traverses the heart, then proceeds to all the parts of the body, and is afterwards directed towards the respiratory organs. But in this latter part of its course, the blood is not always contained in vessels properly so called. Sometimes the veins are altogether wanting, their place being supplied by lacunæ, or void spaces filling up the intervals of the organs; at other times veins exist in some parts of the body, whilst elsewhere in the same animal their place is supplied by venous canals, having no proper tunic, but consisting merely of the interorganic lacunæ, or the large cavities of the body, as the abdominal cavity (*m*, Fig. 53). Finally, the blood, after having undergone the action of the air, returns to the heart to commence its course anew.

§ 111. *Crustacea.*—In lobsters, crabs, and other animals of this class, the blood follows the same course as in the mollusca; only the heart, destined to transmit the blood to all parts of the body, consists of a single ventricle (Fig. 50), and the veins are everywhere replaced by irregular cavities, which have not the form of vessels, and which constitute, in the neighbourhood of the branchiæ, a sort of reservoirs, called venous sinuses (Fig. 54). The venous blood thus bathes all the organs; but the nourishing fluid is once more collected into vessels, whence it proceeds from the gills to the heart. The circulation is, consequently, semi-vascular and semi-lacunar.

§ 112. *Insects.*—In insects the blood is no longer contained in any particular system of vessels; there are neither arteries nor veins, and the nourishing fluid is spread about in the interstices of the organs; still the circulation, such as it is, is animated by the action of a vessel called dorsal, situated in the mesial plane of the body above the digestive tube (Fig. 55). We shall consider, further on, the route followed by the blood in the organism of those animals with a lacunar circulatory apparatus.

§ 113. *Worms.*—In the worms of the class annelides (such

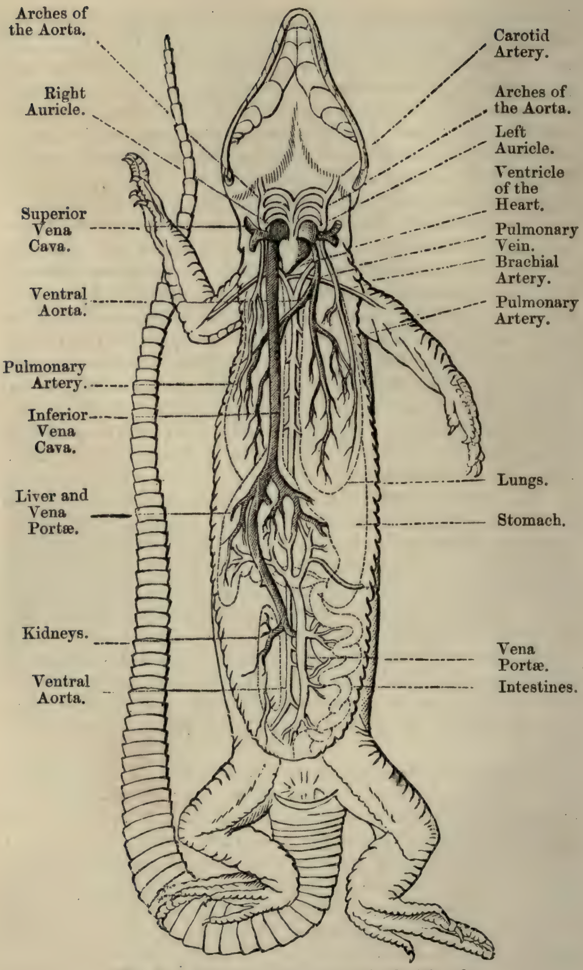
Arches of the Aorta.
Right Auricle.
Superior Vena Cava.
Ventral Aorta.
Pulmonary Artery.
Inferior Vena Cava.
Liver and Vena Portæ.
Kidneys.
Ventral Aorta.
Carotid Artery.
Arches of the Aorta.
Left Auricle.
Ventricle of the Heart.
Pulmonary Vein.
Brachial Artery.
Pulmonary Artery.
Lungs.
Stomach.
Vena Portæ.
Intestines.

Fig. 51.—Circulatory Apparatus in the Lizard.

as the leech and earth-worm) there exists, on the other hand, a complete vascular apparatus; but generally there is no heart, properly so called, and the blood is set in motion by

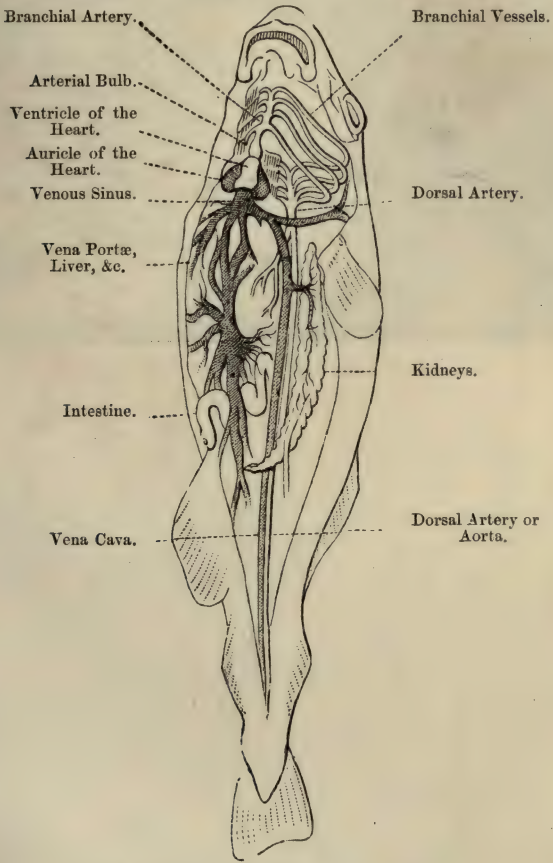
Branchial Artery.
Branchial Vessels.
Arterial Bulb.
Ventricle of the Heart.
Auricle of the Heart.
Venous Sinus.
Dorsal Artery.
Vena Portæ, Liver, &c.
Kidneys.
Intestine.
Vena Cava.
Dorsal Artery or Aorta.

Fig. 52.—Circulatory Apparatus in the Fish.

movements of the vessels themselves, by contractions of the principal vessels. Thus the course of the blood is much less

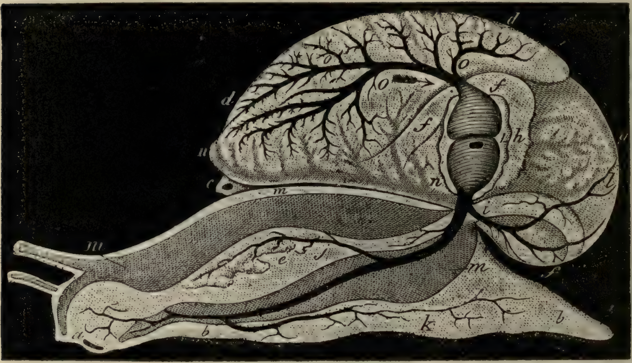

Fig. 53.—Circulatory Apparatus in a Mollusk.*

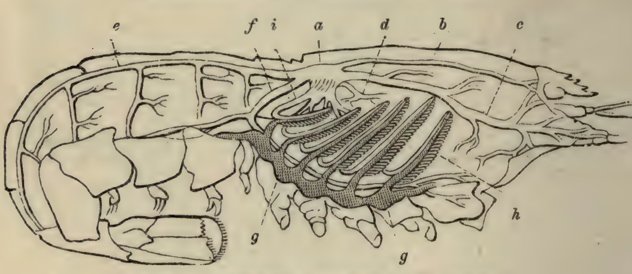

Fig. 54.—Circulatory Apparatus in the Lobster.†

* Anatomy of the Snail.—*a*, the mouth; *b b*, the foot; *c*, the anus; *d d*, the lung; *e*, the stomach, covered above by the salivary glands; *f f*, intestine; *g*, the liver; *h*, the heart; *i*, aorta; *j*, gastric artery; *l*, hepatic artery; *k*, artery of the foot; *m m*, abdominal cavity, supplying the place of a venous sinus; *n n*, irregular canal in communication with the abdominal cavity, and carrying the blood to the lung; *o o*, vessel carrying the blood from the lung to the heart.

† *a*, the heart; *b*, the ophthalmic artery; *c*, the antennar artery; *d*, the hepatic artery; *e*, superior abdominal artery; *f*, sternal artery; *g g*, venous sinuses, receiving the blood coming from various parts of the body, and transmitting it to the respiratory apparatus (the branchiæ, *h*), from whence it returns to the heart by the branchio-cardiac vessels, *i*.

regular than in the various animals of which we have just spoken, and frequently the direction is not constant.

§ 114. *Zoophytes.*—There exists even in some zoophytes, as in polyps, a kind of circulation, produced by the action of the vibratile cilia with which the walls of the cavity, acting at once as stomach and intestine, are provided. By means of these cilia the contained liquids are kept constantly in motion. This cavity is sometimes single, but in some it sends branches to various parts of the body.

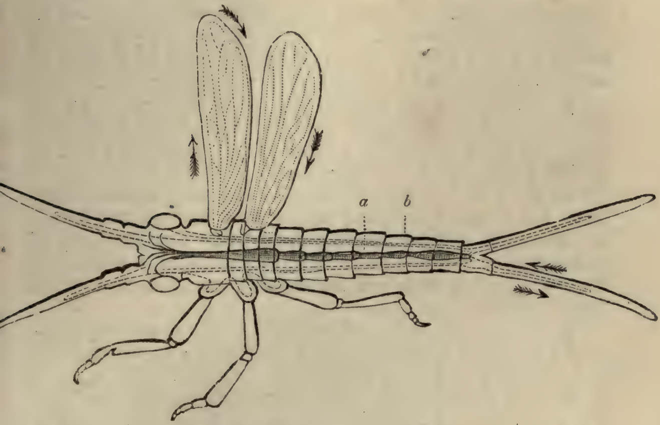

Fig. 55.—Circulation in Insects.*

§ 115. Such are the principal modifications hitherto observed in the mode by which the circulation of the blood is effected in various classes of animals. Let us now consider the phenomena which happen whilst it passes through the circulatory apparatus.

OF THE RESPIRATION.

§ 116. The arterial blood, by its action on the living tissues, loses its vital properties, which can only be restored

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[*] The arrows point out the direction of the currents :—*a*, dorsal vessel, in which the blood moves from behind forwards ; *b*, principal lateral currents.

to it by being exposed to the action of the air whilst traversing in vessels an organ adapted for this purpose. This process of aeration is called respiration. The necessity for this is proved by the simple experiment, if any such were wanted, of placing an animal under the receiver of an air-pump, and exhausting the air; in a certain time the animal dies asphyxiated. Wherever there is life, whether animal or vegetable, air is essential. The term applies equally to aquatic animals, which live by means of the air held in a kind of solution or mixture by the waters in which they exist.

§ 117. The air we breathe, and which is essential to all that lives, is a compound fluid. It is composed of,—1. Watery vapour, always present in greater or less quantities; and 2. In 100 parts of pure atmospheric air: there are 20 of oxygen, 79 of azote or nitrogen, with some traces of carbonic acid gas. Oft-repeated chemical experiments have proved that it is the oxygen alone which maintains life. The discovery of this singular fact we owe (1777) to Lavoisier, a celebrated French chemist, who was barbarously executed during the French Revolution.

§ 118. By the action of respiration the oxygen is withdrawn from the atmosphere, and disappears; in its place we find carbonic acid gas; this gas is not respirable, *i. e.*, if breathed it destroys life. In the consumption of oxygen and the production of carbonic acid gas, respiration essentially consists.

§ 119. Although azote or nitrogen be not a vital gas, its presence in the atmosphere seems necessary to dilute the oxygen: and it has been observed that a certain quantity of azote is absorbed and given out in the act of respiration.

§ 120. Finally, there escapes with the fluids expired a certain amount of vapour, which becomes conspicuous in cold weather; this vapour is called pulmonary transpiration.

§ 121. It is whilst passing through the capillaries of the lungs that the blood loses its dark venous hue, and becomes of a bright vermilion arterial colour. Many experiments have been made to prove that which seems obvious without any.

§ 122. *Theory of Respiration.*—What becomes of the oxygen which has disappeared, and what is the source of the carbonic acid gas uniformly found as a product of respiration? The strong analogy existing between the phenomenon of combustion, of a piece of charcoal for example, and respiration, induced Lavoisier to conjecture them to be almost identical processes; in both, the oxygen disappears, carbonic acid gas is formed, and heat is disengaged.

But this theory must be abandoned, as opposed to subsequent experiments and facts; carbonic acid gas exists already formed in the blood, and is simply exhaled from the surface of the vessels, whilst the oxygen is absorbed into the blood, to be dissolved in it, and to bestow on its particles their living qualities, characteristic of arterial blood.

§ 123. A simple experiment, made by William Edwards, suffices to place this matter in a clear light. Place in a close vase filled with nitrogen or azote, a frog; in this gas the frog can live for a considerable time. Now analyze it, and you will find that, although deprived of oxygen, the animal continues to give out carbonic acid gas. There can then be no combustion, as Lavoisier supposed.

§ 124. In fact, the blood always contains carbonic acid gas dissolved in it; and Magnus has shown that the blood can dissolve a certain measure of any gas with which it may be brought in contact by giving out a portion of the gas first absorbed when dissolving a portion of the second. Thus, by agitating blood in hydrogen, a certain amount of gas is absorbed, and a certain quantity of carbonic acid gas is set free. The same happens when oxygen is used instead of hydrogen, and the blood assumes an arterial character.

§ 125. It results, indeed, from numerous experiments, that, as the changes observed to take place during respiration equally happen to blood when contained in a bladder, oxygen disappearing by being absorbed through the walls of the bladder, and carbonic acid gas appearing, which must have come from the blood and equally passed through the walls of the bladder, the phenomena of respiration must in a great measure be chemical, since they take place as well in blood withdrawn from the body as in the pulmonary vessels.

§ 126. What happens in the respiratory act seems to be as follows: the venous blood coming from all parts of the body reaches the lungs, holding in solution a considerable amount of carbonic acid gas, a little azote, and some traces of oxygen. As it passes through the lungs it comes as it were in contact with the air, and dissolves a portion; oxygen and a certain amount of nitrogen are thus absorbed, and these gases by being thus taken into the blood, expel a certain amount of carbonic acid gas and of azote; the carbonic acid gas exhaled equals pretty nearly the amount of the oxygen absorbed; the azote exhaled and absorbed are nearly equal, and in addition there is the vapour or pulmonary transpiration. Thus the blood loses carbonic acid gas, azote, and water, whilst it becomes charged with oxygen and azote; and thus it may be proved that arterial blood holds dissolved much more oxygen than venous blood, and that it is to this gaseous fluid that arterial blood owes its colour and qualities. *Respiration consists, then*, in the phenomena of absorption and exhalation, by means of which the venous blood, coming in contact with the atmospheric air, parts with its carbonic acid, and becomes charged with oxygen.*

As regards the source of the carbonic acid gas contained in the blood, and thus exhaled during the respiratory act, there is reason to believe that it originates in the union of the oxygen absorbed with the carbon of the organic particles in all parts of the body, whether contained in the blood or removed from the living tissues. The *essential* act, then, of respiration seems to be a combustion going on in the depth of the tissues, and the exchanges effected in the lungs are only the preliminaries to this work.

§ 127. *Activity of Respiration.*—Respiration, essential to all life, varies in activity in different animals.

In birds it is the most active; they consume more air in a given time, proportionally, than any other class of animals, and they soonest die asphyxiated when deprived of it.

Mammals have also a very active respiration, and many experiments have been made to determine the quantity of oxygen required by man in a given time. Now this has been found to vary with age and a variety of circumstances; about 500 quarts, or rather more, per day, may be assumed to be the average. Now, oxygen forms only 21 per cent. of the atmospheric air: hence about 2750 quarts of air are required per hour for the support of this respiration.

Animals of the inferior classes generally, and especially those living in water, have the respiration much less active.

To meet this enormous consumption of oxygen, which would surely end in the destruction of life on the globe if not obviated, nature employs the respiration of plants.

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* It is right to observe, that the quantity of carbonic acid gas contained in the blood, though small, is sufficient to account for the volume of this gas set free during respiration. Thus, in man the blood contains at least $\frac{1}{5}$th of its volume of gas, and as the quantity of blood which traverses the lungs in a minute may be valued at 250 cubic inches, about fifty cubic inches of this gas must pass in the same time. Now the highest valuation of the gas given off in respiration during a minute does not exceed twenty-seven cubic inches.

Vegetables absorb the carbonic acid gas spread through the atmosphere, and under the influence of the sun's rays they extract the carbon, and set free the oxygen. Thus animals supply carbon to vegetables, while the latter return oxygen to animals.*

§ 128. There exists a kind of relation between the vivacity of the movements of any animal and the activity of its respiration, which may be estimated by comparing the movements of a frog and butterfly.

§ 129. The activity of the movements varies also in the same animal according to the circumstances in which it is placed; and it may be established as a general rule, that whatever diminishes the vital energies tends to diminish the quantity of oxygen absorbed and of carbonic acid given out; and *vice versâ.*

Thus in young animals during sleep and after fatigue, the respiratory act is not so energetic as when the opposite circumstances prevail. Let us now attend to the organs by which this important function is carried on, and their various modifications in different animals.

Apparatus of Respiration.

§ 130. In animals of very simple organization there exists no special respiratory organ. They absorb the air by the general envelope of the body. This happens also in the higher animals, and even to man himself; but in all the higher animals a special organ is provided for this act; its vascularity and softness, and spongy character, contrasting strongly with the external integuments of the body.

§ 131. Again, these organs are modified according as the animal is aquatic, properly so-called, or terrestrial and aerial. In the former, the organs are called gills or branchiæ; in the latter, lungs or tracheæ.

§ 132. *Organs of Aquatic Respiration.*—Gills vary much in their form. Sometimes they more resemble tufts or tubercles, which have a texture softer than the rest of the skin, and are better supplied with blood. In others, these organs are composed of a number of branched filaments, and resemble little trees or vascular branches (*a a*, Fig. 56). Finally, in others, they are formed in small membranous lamellæ, disposed like the leaves of a book, or like the teeth of a comb. The first of these arrangements takes place in many marine animals, as in the arenicola, so common on the coasts. The second may be observed, also, in several of the annelida and in some of the crustacea. Finally, the last is common to most molluscan animals and fishes.

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* It might be supposed that the air of cities must be less pure in respect of the amount of oxygen than that of the country; but experiment shows that this is not the case.

It is also to be observed, that in the inferior animals the branchiæ are mostly situated externally, so as to float freely in the surrounding water; whilst in the more highly organized, as the mollusks and fishes, the branchiæ or gills are enclosed in a cavity, into which the water has free access, and may easily be renewed.

§ 133. *Organs of Aerial Respiration: Respiration in Air.*—The organs serving for this form of respiration affect sometimes the form of trachea, sometimes of lungs.

The tracheæ (Fig. 56) are vessels which communicate with the exterior by apertures called *stigmata*, and ramify in the depth of the organs. They convey the air to these organs, and thus the function of respiration is carried on in every part of the body. This mode of breathing is peculiar to insects and to some arachnidæ (spiders).

§ 134. The lungs are pouches, more or less divided into cells or cellules, which also receive air into their interior, and whose walls are traversed by vessels containing blood, thus exposed to the vivifying action of the air.

There exist lungs, but in a state of the greatest simplicity, in most spiders; and in some mollusks, as in snails. Reptiles, birds, and mammals also have lungs.

§ 135. In man, as in all mammals, the lungs are lodged in a cavity, called the *thorax*,

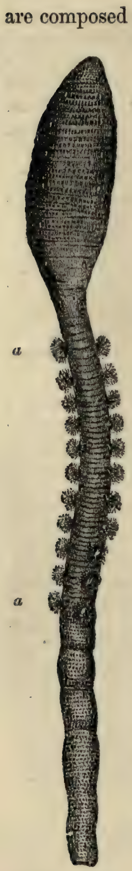

Fig. 56.—The *Arenicola.* Sea Worm—Lob or Lug Worm of Fishermen.

occupying the upper part of the trunk (Fig. 5, p. 20). These organs are, as it were, suspended in this cavity, and are enveloped by a membrane or membranes (one for each lung in most mammals) called the pleuræ; and these membranes, like

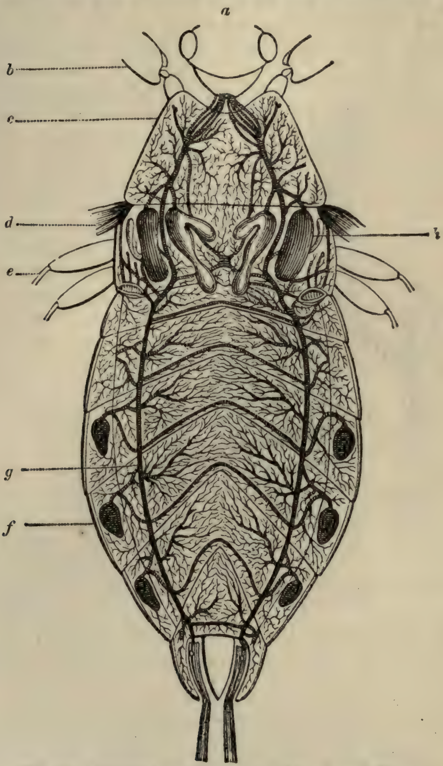

Fig. 57.—Respiratory Apparatus of the Insect *Nepa;* Water Scorpion.*

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* *a*, the head; *b*, base of the feet of the first pair; *c*, first ring of the thorax; *d*, base of the wings; *e*, base of the feet of the second pair; *f*, stigmata; *g*, tracheæ; *h*, aerial vesicles.

all serous membranes, besides investing more or less completely the exterior of the organs, also line the walls of the thorax, thus providing for the security and mobility of the organs themselves.* The lungs are two in number, communicating with the exterior by means of a single air-tube, the trachea (*b*, Fig. 58), which ascends through the fore part of the neck, and opens into the pharynx.

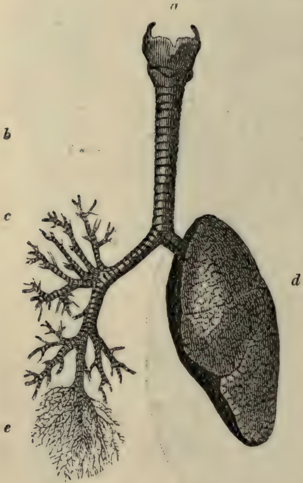

Fig. 58.—Lungs and Trachea in Man.‡

This canal or tube is formed of a series of small cartilaginous bands, incomplete behind. It is lined by a mucous membrane, which is of the same nature as the mucous membrane of the mouth and nostrils, and is continuous with it.† Finally, inferiorly, the trachea subdivides into two branches called bronchi, which ramify in both lungs like the roots of a tree in the soil (*c e*, Fig. 58).

§ 136. The lungs show internally a vast number of small cells, into each of which a branch of the corresponding *bronchus* opens. A soft, delicate, and vascular membrane lines the walls of these cells and air tubes, and it is to these that the alternate branches of the pulmonary artery are distributed, by means of which, now become capillaries, the venous blood is exposed to the action of the air.

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* The pleuræ are arranged, in fact, like other serous membranes.

† The surface of the membrane of the trachea is covered with a fine down, each hair of which exhibits *vibratile* movements, called also ciliary. This vibratile movement determines in the liquid in contact with their surface, currents, which are often very rapid, and which persist even after a portion of the membrane has been removed from the body. The cilia are microscopic. The direction of the current seems to be from the exterior towards the interior, and the same movements may be observed on the surface of the nasal fossæ, but nothing of the kind is to be seen in the pharynx.

‡ One of the lungs (the left) is left in its natural condition (*d*); but in the other the substance has been destroyed, in order to expose the right bronchus and its ramifications in the lung.

a, larynx and superior extremity of the trachea; *b*, trachea; *c*, division into bronchi; *d*, one of the lungs; *e*, bronchial ramusculæ.

The smaller the cells, the greater will be the extent of the membrane, and the more extended the surface upon which the blood is exposed to the action of the air. The smallness of the cells and the activity of respiration are thus in a direct ratio to each other; and this is proved by contrasting the large pulmonary cells in the lungs of the frog with the microscopic cells which we find in the lungs of birds and mammals.

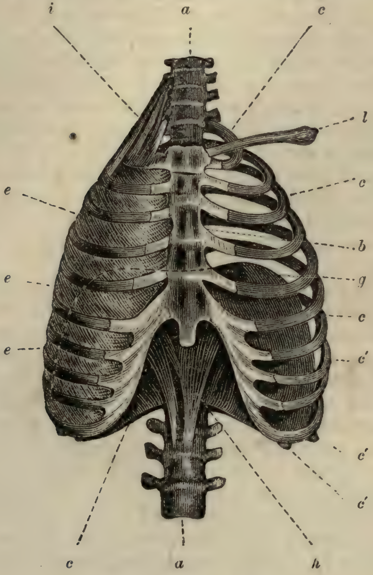

Fig. 59.—Thorax of Man.*

§ 137. But air, as air, never penetrates beyond the little cells, or *cul de sacs*, in which the air tubes terminate in mammals. In birds, some of these air tubes open into large membranous pouches, which proceed as far as the limbs, and conduct the air even into the interior of the bones. Thus respiration becomes more active in this class of animals.

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* On the left side the muscles have been removed. The arch forming the diaphragm towards the interior of the chest is seen on the left side, *g*, and on the right side a dotted line marks the extent of the ascent of the same muscle on the right side; *h*, pillars of the diaphragm attached to the lumbar vertebræ; *i*, elevator muscles of the ribs; *d*, collar-bone.

§ 138. *Mechanism of Respiration in Man.*—By the movements of inspiration and expiration performed by the walls of the thorax or chest, the air is constantly renewed in, and expelled from, the lungs. The walls of the chest are moveable, and more especially one, which is not seen, the diaphragmatic wall; dilated by a muscular effort, the air rushes into the cavity through the nostrils and trachea, pressed on by the whole weight of the incumbent atmosphere. To expel the air from the lungs, it is only necessary that this muscular action should cease for an instant; a forcible expiration is effected by means of a voluntary effort, and is only used occasionally. Respiration is wholly an instinctive action.

To understand its mechanism, so simple in its results, so complex in the machinery, it is first necessary to examine the structure of the thorax.

This cavity (Fig. 59), has the form of a conoid, with the summit upwards and the base downwards, and its walls form a kind of cage, with an osseous basis composed of the ribs, the sternum, and a portion of the vertebral column. The spaces left between the ribs are filled with the intercostal (internal and external) muscles; the scaleni pass from the cervical vertebræ to the first and second ribs; powerful muscles also proceed from the shoulder and arm-bones to the ribs, thus contributing in every way to enable the animal to act powerfully during inspiration, when the great muscular efforts of the body are being made; and in addition, and that the most important of all, the abdominal wall of the thorax is formed chiefly by the diaphragm, the great muscle of respiration.

§ 139. The dilatation of the chest may be effected in two ways—by the contraction of the diaphragm or by the elevation of the ribs.

In repose (expiration) the diaphragm forms an arch towards the chest; in action (inspiration) it contracts and descends towards the abdomen, pushing the contents of the abdomen before it. Thus the capacity of the chest is enlarged, and as the vacuum thus formed in the lungs is gradually being established, the external air rushes in to fill up the space.

The play of the ribs is rather more complex. These osseous arches, extending from the vertebral column to the sternum (with the exception of the lower ones), and articulated with both, are much lower anteriorly than posteriorly, and thus admit of elevation and depression. As the ribs are raised, they rotate on themselves, and thus the cavity of the chest becomes enlarged in all directions. They raise the sternum with them.

§ 140. In expiration, the diaphragm is relaxed; the external air acts on the walls of the chest; the elasticity of the lungs assists, and thus the air is expelled from the lungs; the intercostal muscles also cease to play. But in forcible expiration generally, partly a voluntary act, the muscles of the abdomen and others assist in forcing the air from the lungs.

§ 141. Under ordinary circumstances, the amount of air taken in at each inspiration does not exceed the seventh part of what they can contain; on an average it may be estimated at about the third of a quart. The number of the respiratory movements varies with age and a variety of circumstances. They are most frequent in the young; in the adult the average is sixteen per minute.

Thus, during ordinary circumstances, there enters into the lungs of an adult male about 5½ quarts of air per minute, or about 330 by the hour; 7920 by the day.

§ 142. Sighing, yawning, hiccup, laughter, and sobbing, are but modifications of the ordinary actions of respiration.

Sighing is a deep and prolonged inspiration, not always caused by a moral sentiment, but occasionally by a feeling that the respiratory act does not proceed with sufficient energy and rapidity.

Yawning is an inspiration still deeper, accompanied with an almost involuntary and spasmodic contraction of the muscles of the jaw and pendulous palate.

Laughing seems to depend on a series of rapid movements of the diaphragm; sobbing differs but little from laughing, though expressing passions and feelings of so opposite a character.

§ 143. *Mechanism of Respiration in other Animals.*—The mechanism of respiration is essentially the same in all mammals, birds, and reptiles; in the two latter classes, however, the diaphragm is more or less completely absent, and in consequence it is principally by the play of the ribs that the air is drawn into the lungs; in the *chelonia* (turtle and tortoise), and the *batrachia* (frogs, salamanders, &c.), the thorax is not formed so as to act as a suction pump, and accordingly these animals swallow the air by a sort of deglutition.

OF EXHALATION AND THE SECRETIONS.

§ 144. We have seen how the nutrient matter is distributed to all parts of the body by means of the blood; we have now to examine how the matters contained in the general mass escape from it, whether into the interior or directly from the body.

§ 145. Nutrition we have seen to be effected in two ways; either, 1st, by the simple absorption into the body of matters requiring no modification: 2nd, by the more complex function of digestion: the first is almost mechanical; the second partakes more of a chemical character.

In like manner nature, in freeing the body of the useless substances and the necessary results of vital actions, employs two methods of expulsion, *exhalation*, and *secretion*. The first of these processes is almost physical, and depends on the permeability of the tissues; by the second, peculiar substances are selected from the blood, and eliminated, as it were, in order to be expelled the body; to effect this, certain organs are required, and these are called secreting organs. The process bears to simple exhalation the relation which digestion does to absorption.

EXHALATION.

§ 146. The walls of the bloodvessels are permeable to liquids. By this means, water, gases, and the thinner parts of the blood generally, may pass through these walls by exhalation; but they do not admit of the passage in this way of the globules, or denser parts of the blood. This is proved by injecting prussiate of potass into the veins of a living dog; the salt injected may be soon after detected in the thorax and abdomen, mingled with the fluids, which are constantly exhaled on the surface of serous membranes. Spirituous and other liquors are perceivable in the breath soon after being taken.

§ 147. *Mechanism of Exhalation.*—Exhalation is purely a physical phenomenon, however it may be modified by the presence of life. Thus, if into the vascular system of an animal, recently dead, an injection be thrown, composed of gelatine, mingled with vermilion finely powdered, the fluid part of the injection will escape into the adjoining tissues, leaving the vermilion particles in the vessels; thus imitating what seems to take place during life.

§ 148. In fact, inhalation, already explained, and exhalation are strictly analogous, and take place in the same way; and their activity depends on the spongy and vascular character of the tissue. In another sense, these functions are in the inverse ratio of each other. By pressure on the veins, the exhalation into depending parts may be much increased.

§ 149. *Seat of the Exhalation.*—Exhalations are either *external*, that is, on the surface of the body; or *internal*, that is, on the surface of the internal cavities.

§ 150. *External exhalation* must not be confounded with perspiration, or production of sweat; it takes place on the surface of the lungs as well as on that of the body, and is called *insensible transpiration*, because, being evaporated by the air, it escapes our notice. Men and animals lose much daily by insensible transpiration, which, of course, is as constantly restored; according to Sanctorius, the loss by insensible transpiration in man amounts to $\frac{5}{8}$ths of the whole daily loss. The evaporation from the surface of the body varies with many circumstances, as climate, &c.; the escape of carbonic acid gas from the lungs is by means of exhalation merely.

§ 151. The serous membranes found in the interior of the large cavities of the body are the seat of internal exhalations, consisting chiefly of water, and a few salts, mixed with a small quantity of animal matter. The exhalation which takes place on these surfaces has an exact counterpoise in the absorption going on at the same time; when this is disturbed the fluid accumulates, and dropsies take place, which receive names according to their localities: hydrocephalus, in the head; ascites, in the abdomen; hydrothorax, in the chest and pleuræ; and hydrops pericardii when the accumulation takes place within the cavity of the pericardium.

SECRETIONS.

§ 152. The secretions are special humours, formed at the expense of the blood, in and by organs destined especially to eliminate them from the blood.

§ 153. They may take place on the surface of membranes, as on the skin and mucous membranes; but they are chiefly found in connexion with certain bodies termed glandular, whose essential structure seems to consist in small cavities, extremely minute, or pouches or canals of extreme tenuity; these receive bloodvessels and nerves, the latter no doubt playing an important part in the phenomena of secretion. The glands have been divided into perfect and imperfect, according as they are provided or not with a tube or duct intended to carry away the product of the secretion.

§ 154. Glands, properly so called, may all be arranged, as regards their intimate structure, under two heads, or types; as being composed either of small sacs, with orifices more or less contracted, or of tubes of extreme minuteness; and the differences they present have a reference mainly to the mode in which these, as it were elementary, structures are grouped.

§ 155. The small secreting sacs are called follicles, when shallow they are called *crypts*, and many such may be seen on the surface of mucous membranes. When each has a separate or distinct orifice opening on the surface, they are called simple follicles, and many such exist on the surface of the mucous membranes; if grouped close together, but *still* maintaining distinct orifices, they are called *aggregated;* such are the glands of Meibomius on the eyelids, certain gastric glands in some animals, &c.; when grouped, but having their orifices leading into a small cavity common to

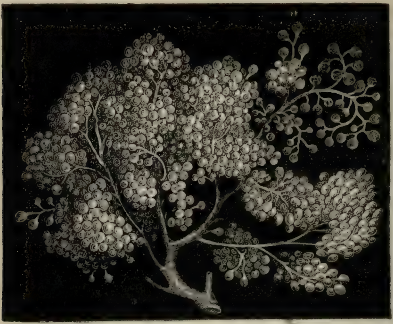

Fig. 60.—Intimate Structure of a Composite Gland (the Parotid); a Salivary.

all, and thus ultimately communicating with the surface by one or more apertures only, as in the amygdalæ or tonsils, they are called *agglomerated follicles.* At other times little sacs, which form the essential structure of the glandular bodies we now speak of, communicate with the exterior by an elongated neck, so as to resemble a tube, terminated by an ampulla, and there they may either remain isolated or agglomerated in bunches, by means of common excretory tubes, which, in their turn, reunite successively, to terminate by a single duct (Fig. 60). The secreting organs, which may be called *ampullary follicles,* are met with in the simplest form under the skin of certain fishes, and seem also to form the odoriferous glands found in the human integuments. When grouped around a common branched secreting canal (Fig. 60), they form the greater number of the *composite glands,* such as the liver and salivary glands of mammals, and are named by anatomists, *Conglomerate Glands.*

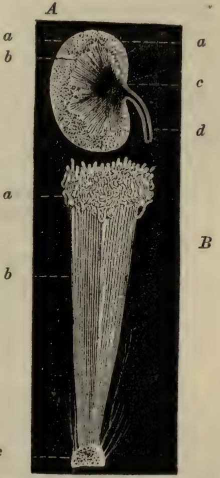

Fig. 61.—Structure of the Kidneys.*

§ 156. The *tubular*-formed secreting organs present also differences analogous to those just described. These tubes vary infinitely in size, but are all closed at one extremity, and open at the other for the escape of the excreted matter; their varied arrangements are seen in the glands under the integuments in fishes, and in the bilious vessels of some of the lower animals; in the pancreatic cœca surrounding the duodenum in fishes; in the gastric glands of several birds; finally, these same tubes (Fig. 61) may acquire an extreme length without change in their calibre, clustered or heaped on themselves, to terminate in an excretory tube, but little ramified at its origin, in such a way as to form a conglomerate gland, such as the kidneys and other glands of great importance: some glands have a reservoir placed in the course of the excretory duct, intended to permit of the accumulation of the secretion, and its residence therein for a time. The gall-bladder (Fig. 33) and the urinary-bladder (Fig. 62) are pouches of this nature.

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* *A*, vertical section of a kidney.—*a*, cortical substance; *b*, tubular substance; *c*, calyx and pelvis; *d*, canal of the ureter.

B, intimate structure of this gland.—*a*, terminal portion of the urinary tubes; *b*, medullary portion of these same tubes; *c*, their termination in the calyx.

§ 157. The *imperfect glands* vary still more in their mode of conformation. Some are composed of small closed cells, isolated or agglomerated; others, called *vascular ganglias,* are composed of bloodvessels or lymphatics solely, which, after dividing and subdividing, again reunite. As examples of the first may be cited the ovarian vesicles and the adipose cellules; of the second, the thyroid,* the thymus,† the spleen (Fig. 32), and the mesenteric ganglias are the examples (§ 75). Their functions are unknown.‡

§ 158. *Nature of Secretion.*—The secreting organs are always disposed in the form of membranes, one surface of which is bathed by the nourishing fluid,§ the other being free and forming the interior of the cavity; this is the utricular surface. This surface, then, performs, as it were, the office of a filter, allowing only certain substances to pass from the interior of the bloodvessels into the interior of the secretory tube.||

§ 159. The secretions differ from each other, and from the blood, out of which they are formed, in containing substances in great abundance, of which but very small quantities are to be detected in the blood: they may contain free acids, whilst the blood from which they are drawn is alkaline;

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* The thyroid is a spongy, ovoid, vascular mass, of a glandular appearance, placed in the neck, and attached to the front of the trachea. Its enlargement constitutes bronchocele, and when aggravated, *goitres.* It is not present in birds, reptiles, and fishes, and in animals still lower.

† The thymus is a glandular-looking body, extremely developed in the fœtus, but which diminishes after birth, and generally altogether disappears. It is situated in the fore and upper part of the chest, behind the sternum, and between the mediastina. It lies partly on the pericardium.

‡ The recent experiments of M. Bernard seem to show that the liver, in addition to its other functions, secretes a sugary substance, called *glycose,* which it pours into the blood, but which disappears soon after, probably consumed by the respiratory act.

§ The blood-vessels distributed to the walls of the tubes and cavities forming the secreting organs never communicate directly with their internal cavities.

|| Recent observations seem to show that the essential secreting organs are minute cellules or utricles, of which the inner wall of the secreting tubes are formed; these little cells empty themselves first, or are thrown off into the interior of the tubes, and are as rapidly restored or renewed. They form the layer called *epithelium,* forming the inner layer of all mucous membranes.

sometimes they also are alkaline, but much more strongly than the blood; whilst some are characterized by the presence of matters not to be found elsewhere, such as urea, casein, butter, &c.

§ 160. It is probable that in all cases the secreted matter exists in the blood already formed. It was thought, for example, that the urea found in urine must be formed by and in the kidneys, since it could not be detected by chemical analysis in the blood; but if these organs be destroyed in a living animal, or removed, urea will, after a certain time, be formed in the blood, thus clearly proving that the kidneys do not form it.

§ 161. *Nature of the Secreted Liquids.*—There is no perceptible relation between the nature of the fluid and of the gland secreting it; and secretions, as pus, for example, are formed by structures where no such secretion previously existed; they alter also without any visible change in the structure of the gland.

Nothing positive is known as to the nature of the secreting function, but it is certain that the action of the nervous system has a great influence over it. When the nerves of the stomach have been divided in a living animal, the secretion of the gastric juice ceases; and M. Bernard has shown that when a certain portion of the spinal marrow is irritated, an unusually abundant secretion of sugar takes place in the liver, which sugar then appears in the urine.

This fact is remarkable, viewed in connexion with the disease called *diabetes.*

Urinary Secretion.

§ 162. This function has its seat in the kidneys, two large glands situated in the abdomen, on either side of the vertebral column, and generally surrounded with much fat. They are of a reddish-brown colour, and in shape resemble a kidney-bean (Fig. 62). Their substance (Fig. 61) is composed essentially of secreting tubes of extreme tenuity, and of great length, which in mammals are turned on themselves in every direction towards their free extremity, where they swell into the form of an ampulla (*a*), and which afterwards proceed in a straight line towards the middle of the inner edge of the gland, so as to form a certain number of pyramidal fasciculi (*b*), whose summit is partially enclosed by the membranous cavity called calyx (*c*), and whose base, directed outwards, is, as it were, encased in the cortical substance of the kidney, formed out of the mass constituted by that portion of the tubes which is massed into heaps rolled on each other; the other part is called tubular or medullary; being the part formed by the fasciculi themselves. In the young, and in many animals throughout life, such as the bear and otter, these pyramids remain distinct, and each kidney is then composed of several separate lobes; but generally they unite together, and the calyces, which are but excrementory tubes, unite to form a pelvis or general reservoir, from which proceeds the ureter (Fig. 61 *d*). A great number of bloodvessels creep between these secreting tubes, and constitute, in the cortical portion of the gland, a very close network, in the midst of which may be seen certain spherical bodies, formed also of bloodvessels collected into bunches in the interior of the ampulla already mentioned.

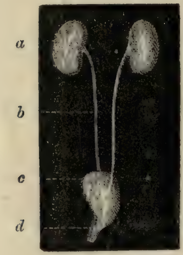

Fig. 62.—Urinary Apparatus.*

The urine is formed in the cortical part of the kidneys. It descends by the tubular part into the calyces, and thence into the pelvis of the kidney; this terminates in the ureter (Fig. 62 *b*), by which the urine descends to the bladder. This latter organ is situated in the pelvis and behind the os pubis. It is formed internally by a mucous membrane; externally, by a muscular and cellular layer. The peritoneum also partially invests it, and gives it support. Inferiorly it terminates in the canal of the urethra, by which the urine escapes from the body.

§ 163. The urine is a yellowish acid liquid, which in man, in the normal state, is composed of 93 parts water, 3 of a peculiar substance called urea; a very small portion of uric acid, lactic acid, various salts, as muriate of soda, alkaline sulphates, phosphate of lime, &c., make up the 100 parts.

In carnivorous mammals the urine resembles that of man, but the uric acid is wanting. In herbivorous mammals, the urine is alkaline, and a peculiar substance is found, the hippuric acid, as well as many earthy carbonates. In many birds, and in most reptiles, the urine is composed mostly of uric acid; whilst in frogs and tortoises (turtles and tortoises) it contains urea and albumen. Its composition in fishes appears to be the same; but in insects we again find uric acid. Disease affects its composition in man.

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* *a*, the kidneys; *b*, the ureter; *c*, the bladder; *d*, canal of the urethra.

§ 164. The extreme rapidity with which various drinks, medicated or simple, pass from the stomach to the bladder, and so escape externally by the urethra, is well known; yet it is certain that these fluids have first mingled with the blood and been by it carried to the kidneys.

§ 165. A variety of circumstances, unnecessary to dwell on, influence the activity of the secretion and modify its character. The liquids, and especially water, taken into the stomach escape either by pulmonary or cutaneous exhalation, or by the kidneys as urine. With heat, the cutaneous exhalation is increased; by cold, the urinary.

The amount of solid substances secreted by the kidneys depends greatly on the abundance and nature of the food. It is diminished during a prolonged fast; and is rich in its solid contents in proportion to the animalization of the food employed.

§ 166. Various deposits are found in the urinary passages. These are called gravel and urinary calculi, or concretions. The former is almost always formed of uric acid. The deposits commence usually, if not always, in the kidneys. Urinary concretions also usually form in the kidneys, but descending from these into the bladder, increase, by deposits on their surface, to a size endangering life, and requiring for their removal a surgical operation.

OF ASSIMILATION AND NUTRITIVE DECOMPOSITION.

§ 167. *Assimilation.*—The substances introduced into the animal economy are there employed in two ways. They serve for the formation of the different parts of the body itself, or to support the respiratory combustion which constantly exists in the interior of every animal so long as life exists.

But neither animals nor plants can of themselves form any of the simple substances of which their bodies are composed, and therefore the foreign matters thus introduced must contain all their elements.

The primary materials of the organism are carbon, nitrogen or azote, hydrogen and oxygen; but sulphur, phosphorus, lime, and other simple bodies, are also required; it is essential, then, that such bodies should be introduced from without. But animals do not possess the faculty of determining the combination of these various chemical elements so as to give rise to the various compound principles of which the organism is formed; or, in other words, these elements must be already combined. Thus, it is not by introducing azote, hydrogen, carbon, &c., into the body that an animal can satisfy the wants of nutrition; these substances must have been already combined.

In a word, these principles must have been already combined, so as to form *organizable* principles or *viable matters.* Now, this only happens through the influence of life. It is the vegetable kingdom, then, which directly or indirectly furnishes to animal bodies the carbon and azote, and a certain portion of hydrogen and oxygen; water furnishes the greater portion of the requisite hydrogen and oxygen; the lime and various other mineral bodies come directly from the mineral kingdom.

From the atmosphere, animals derive the oxygen required to consume the carbon and hydrogen; and thus, in brief, to meet the wants of the nutritive process, every animal requires to convey into the interior of its organization, free oxygen, organized matters rich in carbon, hydrogen, azote, water, and various salts.

Before being adapted for nutrition, all substances must assume a liquid or gaseous form; this is the object of digestion. There exist three modes of ingress for the nutritive matter—the skin, the respiratory mucous membrane, the alimentary canal.

In man and animals which have an epidermis, absorption by the skin is comparatively unimportant; by the lungs, some liquid in the form of vapour is no doubt absorbed; but the intestinal or alimentary canal, by means of its mucous membrane, is the great route by which the matter destined to assist in nutrition reaches the interior of the body.

§ 168. These nutritive elements are at first mingled with the blood. This fluid, elaborated by processes not yet discovered, becomes rich in all the compound principles of which the tissues are in their turn formed; and it is out of this fluid that all the organs of the body draw the materials fitted for their growth and support, each choosing the molecules identical with its own nature.

It is this last act which constitutes *assimilation.*

§ 169. But nothing is known as to the real nature of this act of assimilation, how brought about, how effected. Such questions touch too nearly the very essence of the principle of life, itself perfectly unknown in its nature. One thing is certain, that in all animals possessing a nervous system the influence which this exercises over assimilation is distinct and undeniable. Nor is the duration of life in the various organs of the same animal the same; the thymus gland, for example, ceases to grow, and decays in the very young. The teeth have their stated periods of existence; the nails, the hair, and generally the epithelial tissues, continue to grow in extreme old age.

§ 170. The assimilating force possesses the property, especially in the lower animals, of restoring parts which have been destroyed; bones are reunited by bone after being broken, and even large portions of them which have been lost have been restored. The limb of the lizard when broken off has grown again: a new foot been reproduced in crabs and spiders; in salamanders, a new eye and portion of the head have been restored after the removal of the original parts by amputation. Finally, earth-worms and many other annelides can thus reproduce a great part of the body; and in the hydra and fresh-water polyp (Fig. 4), a small fragment has been found equal to the reproduction of the entire body.

§ 171. Moreover, various circumstances, which we have not the leisure to examine here, may modify the progress of the work of assimilation, render it active, retard it, or change its direction. It is in this way that in certain diseases we see nutrition to be almost entirely arrested, and that in others certain tissues change their nature. It is also to be observed, that this assimilative labour does not take place with the same rapidity in all parts of the body; to be assured of this, we have only to observe the changes in form often brought about by the progress of age; for these changes depend chiefly on this, that certain parts increase more rapidly than others. Thus, from the moment of birth to the adult condition, the members of the body of man grow more rapidly than the trunk; whence it follows that, in general, this latter is a portion the less considerable of the whole as the growth is more prolonged.

§ 172. *Excretion.*—Whilst nutrition is going on, decomposition proceeds *pari passu*, that is to say, the separation of a portion of the molecules of the tissues, and their expulsion from the body. The bones themselves are thus continually decomposed and recomposed; the utricular tissue covering the surface of the ligaments, mucous membranes, and glandular cavities, is being continually renewed and destroyed; and the old epithelium gives way before new layers formed beneath it in the substance of the tissues.

Some physiologists have thought that such a renewal of the constituent parts of animal bodies affects every structure and organ, and that an entire renewal of the body occurs in every seven years. This opinion is not based on direct experiment, and seems, indeed, contrary to the fact. Many organs remain for long periods stationary, although it may be admitted that, under peculiar circumstances, the original tissues themselves may be attacked, as after long fasting. Thus, the curious experiments of M. Chossat show that when birds do not find in their food a sufficient proportion of calcareous matters, the phosphate of lime entering into the composition of their bones is taken away, little by little.

Now, the blood furnishing, as we have seen, the materials of the various humours which the animal economy constantly rejects and expels from it by the route of the secretions, becomes unceasingly impoverished, and might take away from the organs the soluble principles they contain, if the repeated introduction of foreign substances did not maintain this liquid always saturated with the same principles. It results from this, that this introduction of the alimentary matters into the organism is necessary, not only to effect the increase of the living parts, but to secure the conservation or preservation of the tissues already existing, and to prevent the resorption or re-absorption of their constituent materials. In brief, the nutrient matter introduced continually into the blood is necessary, no doubt, not only for the growth of the body, but also to maintain all the organs in their integrity, and to prevent their being acted on by absorption.

Finally, the slow combustion taking place in every part of the body also destroys the combustible matters: and unless this destruction be met by constant renewal, it would seem, from the experiments of Dumas and others, that the oxygen would act on and destroy the materials composing the organs themselves. From the aliments there must come the combustible matters for the oxygen to act on, by means of which they are transformed into carbonic acid gas and water, and in that form eliminated from the body: from the same source are derived the materials of growth and of secretion.

But whether the carbonated and hydrogenated matters thus consumed come from the aliment directly or from the tissues themselves, one thing is obvious, that the loss must be supplied from without, under the form of aliments.

The alimentary matters, which contain only carbon, hydrogen, and oxygen in their ultimate composition, such as fecula or sugar, may be transformed into carbonic acid and water, leaving no residue; but the vital combustion of azotized matters gives rise to other products; and these compounds by losing carbon become richer in azote, and constitute peculiar organic principles, such as urea and uric acid.*

§ 173. Chemistry seems to prove that it is vegetables which fabricate the combustible matters destined to be consumed in animal bodies, plants alone having the power thus to fix carbon under the forms of organic compounds.†

The carbonic acid gas and water escape by respiration; the more solid products, as the urea, by the urine. In the adult animal it would thus seem that there may be found nearly the whole of the elements introduced into the system by the food or by respiratory absorption, in the products of the respiration and urinary secretion, the alvine dejections being composed almost wholly of the indigestible residue of the food, mingled with various secretions.

Before the growth is completed, all the alimentary matter is not burnt or consumed in this way; a part is found in the organism when the carbonaceous matters taken in exceed the power of the oxygen to consume, the result being the deposition of fat, which may afterwards be consumed according to the exigencies of the animal.‡

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* When the tartrate, malate, or citrate of potass has been absorbed or injected into the veins, and, so absorbed, carbonate of potass is found in the urine, thus proving the combustion of the vegetable acid entering into their composition.

† According to the recent experiments of Dumas, Boussingault, and Payen.

‡ The fat is not deposited indifferently in every part of the body. It is composed of two substances, oleine and *stearine*, the proportions of which vary in the fat of different animals. It is abundant in animals which hybernate at the commencement of winter, but disappears towards the close of that season. The fat is supposed to be useful as a cushion for certain organs, as a reservoir to meet the consuming powers of the oxygen taken into the body, and as a preservative of the heat of the body.

To complete this sketch of the phenomena of nutrition, all that remains is to speak of the sources of animal heat.

OF ANIMAL HEAT.

§ 174. Animals vary so much in their different heat-producing powers, that although all produce heat, some are called cold-blooded animals with reference to others. The difference may be shown by comparing the amount of heat produced by a fish and a rabbit, placed in a vessel surrounded with ice; the quantities of ice dissolved will give the amount of the difference, which is enormous; for, after three hours, the heat produced by the fish will scarcely have acted on the ice, whilst that originating from the rabbit will have produced more than a quart of water. Now the amount of heat required to convert so much ice into water will be found equal to that necessary to raise the temperature of three quarts of water from the freezing to the boiling point.

Hence the distinction of animals into cold and hot blooded. In man the heat of the skin varies from 97° to 100° Fahr.; that of the interior of the body is always 100°. It is the same in most mammals. In birds the temperature rises to 108°. The blood in both is hotter.

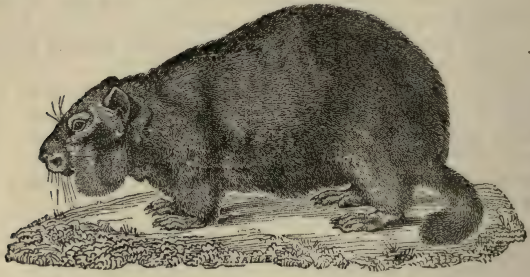

Fig. 63.—The Marmot (*Arctomys marmota*).

§ 175. In general, birds and mammals maintain the same temperature at all seasons of the year and in all climates; but there are some in which the temperature lowers as winter proceeds: these are the hybernating animals, such as the marmot (Fig. 63), the bat, and hedgehog.

§ 176. In the young, the production of animal heat is not equal to what it afterwards becomes, especially in those born with the eyes closed. Thus kittens or puppies left exposed to the air, even in summer, soon die. New-born children also are extremely susceptible of cold.

§ 177. This production of animal heat is evidently connected with the phenomenon of vital combustion, with the absorption of oxygen by the blood, and the production of carbonic acid gas. It seems, in fact, to be proportional to the amount of oxygen absorbed, and hence is greatest in birds and mammals.

The production of carbonic acid gas takes place in the capillary vessels, where, in fact, the arterial blood becomes venous; the production, then, of animal heat is not confined to one spot, as the lungs, but is extended over the whole body. It depends on the arrival of fresh arterial blood, and when the supply of this is cut off or diminished, the temperature is immediately lowered.

There is a remarkable relation also between the richness of the blood in solid parts and the production of animal heat. It is richest in birds (14 or 15 : 100), in whom the animal heat is greatest; next in mammals (9 or 12 : 100); feeblest in the cold-blooded, as in frogs and fishes, in whom the solid parts of the blood, compared to the liquid or watery, is as 6 of globules to 94 of serum.

It bears a certain relation also to the distance from the heart, and thus the limbs are most exposed to be frost-bitten.

Thus it is to respiration that is due the production of animal heat, since it is in the lungs that the oxygen is absorbed. But in the higher animals this combustion itself is evidently influenced by another physiological agent, of which we have not yet spoken—the nervous system.

Numerous experiments have placed this fact beyond a doubt. The late experiments of M. Bernard on the cervical ganglions are in fact not opposed to this view. Toxic agents, which lower the activity of the brain and nervous system, obviously affect the production of animal heat.

§ 178. Hot-blooded animals have the faculty of resisting external heat when raised above the natural temperature of their bodies; this is effected by evaporation from the surface of the cutaneous transpiration, by which the temperature of the body is maintained at nearly the same temperature at the equator or within the polar circle.

II.—OF THE FUNCTIONS OF RELATION.

§ 179. Hitherto we have been occupied with those functions which have for their object the preservation of the individual; let us now attend to those intended to make him acquainted with surrounding objects.

§ 180. Observe carefully the movements of an animal, and you will soon discover that some are obviously ***voluntary***, or directed according to the ***will*** of the animal. Another class of movements may also be observed, over which the animal does not seem to possess the same influence; these are the ***involuntary***. These phenomena imply contractility and volition; but there is to be added another remarkable faculty, ***sensibility***, by which the animal perceives the presence of surrounding objects, and becomes conscious of their presence.

These three faculties seem to be common to all animals; but there are others. Certain animals construct with the most admirable art dwellings for their young and for themselves, and this they do independent of all instruction from the parent. Others proceed on distant voyages and journeys, traversing the air as certainly as if the point to be attained were before their eyes. To this faculty the name of ***instinct*** has been given; it leads animals to perform certain acts which are not the effects of imitation, and which are not the result of reasoning. The phenomena are sometimes very simple, and sometimes incomprehensibly complex.

To other beings are given the faculty of recalling previous sensations, of comparing them with each other, analysing the past and present, and drawing conclusions; these are the intellectual faculties.

Finally, some animals can communicate to others a knowledge of the ideas they possess, by movements or sounds.

These varied phenomena, by which animals place themselves in relation with others, may be reduced to six principal faculties,—namely, sensibility, contractility, will, instinct, intelligence, and expression.

In the simplest animals, these various faculties of the life of relation are not the appanage of any organ in particular; but in man and in the immense majority of animals, the exercise of these faculties is dependent on the action of the nervous system.

OF THE NERVOUS SYSTEM.

§ 181. This system is formed by a soft pulpy substance, which is almost fluid in early life, but acquires more consistence with years. The aspect of this tissue, called nervous, varies much; occasionally white, at other times grey or ash-coloured; in some parts it forms masses or ganglions, in others elongated cords. The cords are called *nerves;* the masses, *ganglions* or *nervous centres.*

§ 182. In man, and in those animals which approach him in structure, the nervous apparatus is composed of two parts—the cerebro-spinal or nervous system of animal life, the ganglionic or nervous system of organic life; and each of these systems is composed in its turn of two parts—a central, composed of the nervous masses, and a peripheric, composed of the nerves which proceed from these centres to all parts of the body (Fig. 64.)

§ 183. *Cerebro-spinal System in Man.*—The central portion of this system, also called the cerebro-spinal axis or encephalon, is composed essentially of the cerebrum, cerebellum, and medulla spinalis, and is lodged in an osseous cavity and canal, formed of the cranium and spinal column.

§ 184. *Envelopes of the Encephalon.*—Three membranes enclose, support, and nourish the cerebro-spinal axis. The first is the dura mater, a fibrous membrane of considerable strength, adhering to several points of the osseous canal, and forming a strong projecting covering for the encephalon. It sends prolongations towards the interior of the cranium, serving to protect various parts of the organ; and in its substance are formed various venous canals or sinuses, in communication with the general venous system of the body.

These sinuses are called sinuses of the *dura mater.*

Within the dura mater is a second membrane, called the *arachnoid.* This is a serous membrane of extreme tenuity, and transparent, but firm, and like all serous membranes, is a sac without any opening into it. By one layer it invests the inner surface of the dura mater, and by the other the brain, thus providing for the movements of the organ.

Beneath the cerebral layer of the arachnoid is the *pia mater,* immediately investing the nervous tissues itself. This is a cellulo-vascular membrane, in which ramify the vessels proceeding to and from the brain; for the arteries especially are, in general, minutely subdivided before they actually

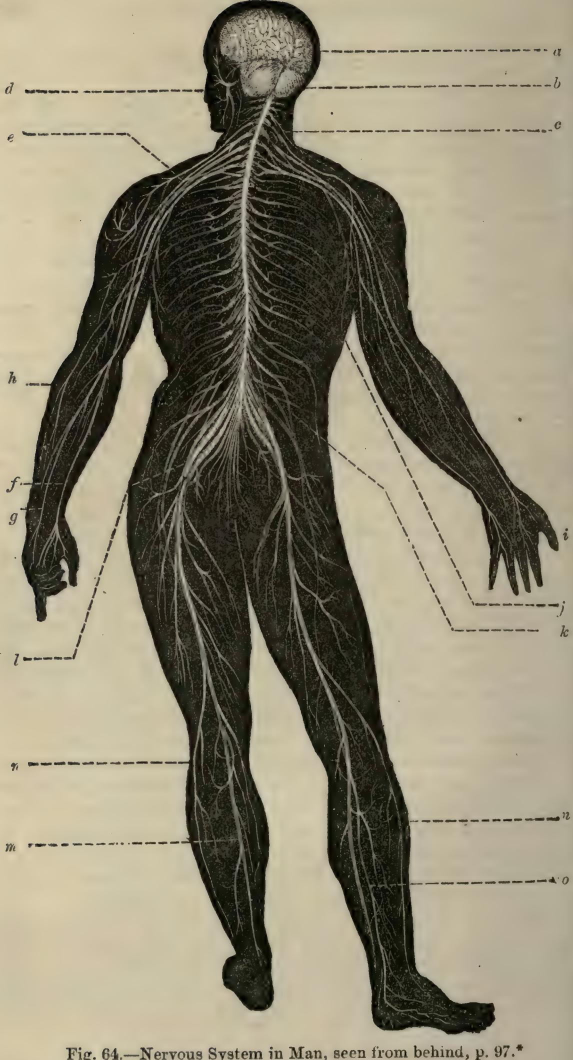
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Fig. 64.—Nervous System in Man, seen from behind, p. 97.*

penetrate the nervous matter. These three membranes invest the entire encephalon, and present thus a spinal as well as a cranial portion.

§ 185. Though composed of several parts, the encephalon may be viewed as one; yet each division seems to perform distinct functions, in a certain sense.

§ 186. The cranial portion is composed of the brain, cerebellum, and pons Varolii; the spinal portion may be viewed as composed of the medulla oblongata and spinal marrow, properly so called.

The brain (Fig. 64 *a*, Figs. 65, 66 *a b c*) (cerebrum) is by much the largest part of the encephalon in man and mammals. The form of the skull, in a general way, represents its shape, more especially in man. The cerebrum proper is subdivided into two hemispheres by a deep mesial fissure, extending quite down to the *corpus callosum* in the middle, and anteriorly and posteriorly separating the hemispheres completely from each other. The corpus callosum unites the hemispheres, and may be called a transverse commissure. In the fissure descends the falx cerebri, a partition formed by the dura mater. On the surface of these hemispheres may be seen the convolutions and *anfractuosités* of the brain so distinct in man, and which have given rise to so much speculation. They are of little depth in very young children and in most animals.

By turning up the brain and examining its base, it is easy to observe, without much dissection, that the brain admits of being divided into three lobes on each side, an anterior, middle, and posterior; this last is not so distinct as the others.

[In point of fact there is no very obvious distinction between the middle and posterior lobes, and it would have been much better had anatomists divided the inferior surface of each hemisphere into *two lobes* only, an anterior and posterior. Thus would have been avoided those silly disputes which have lately occupied the attention of the public about the size and form of the brain in apes as compared with the human brain. The great distinction between the latter and other vertebrate animals is that in man, the posterior lobe of the cerebrum overlaps the cerebellum, whilst in other animals (with scarcely an exception) *it does not.* But the brain in all mammals is formed on precisely the same plan; no parts have been left out.—R. K.]

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* *a*, cerebrum; *b*, cerebellum; *c*, spinal marrow; *d*, facial nerve; *e*, brachial plexus caused by the union of several nerves coming from the spinal marrow; *f*, median nerve; *g*, cubital nerve; *h*, internal cutaneous nerve of the arm; *i*, radial and musculo-cutaneous nerve of the arm; *j*, intercostal nerves; *k*, femoral plexus; *l*, sciatic plexus; *m*, tibial nerve; *n*, external peroneal nerve; *o*, external saphenous nerve.

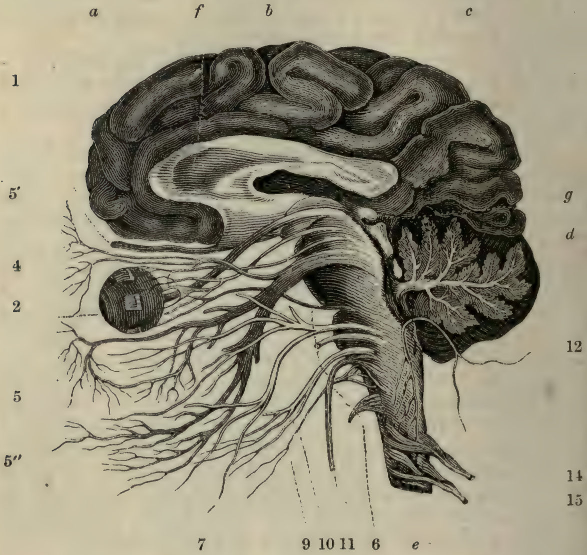

Fig. 65.—Section of the Brain, Cerebellum, Pons, and Medulla Oblongata.*

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* Vertical section of the cerebrum, cerebellum, pons Varolii, and medulla oblongata; *a*, anterior lobe of the brain; *b*, middle lobe; *c*, posterior lobe; *d*, cerebellum; *e*, medulla spinalis; *f*, section of the corpus callosum. The lateral ventricles of the brain are situated on either side of the corpus callosum, which assists in forming their upper wall. *g*, optic lobes: 1, olfactory nerves; 2, the eyeball, from which may be traced the optic nerve as far as the optic thalami or lobes. Close to this is the nerve of the third pair. 4, the fourth pair, distributed, like the third, to the muscles of the eyes; 5, superior maxillary branch of the fifth pair; 5′, ophthalmic branch of the same pair of nerves; 5″, inferior maxillary branch of the same pair of nerves; 6, sixth pair, proceeding to the abducentes muscle; 7, facial nerve;—under the origin of this nerve may be seen a portion of the acoustic; 9, nerve called glossopharyngeal; 10, pneumogastric nerve; close to it is, 12, the spinal accessory; these three nerves, the glosso-pharyngeal, pneumogastric, and spinal accessory, are by some reckoned as one pair; 11, the ninth pair of some, and the eleventh of others, called also hypoglossal; 14 and 15, cervical nerves.

It is on this surface also that the cerebellum may be distinctly seen, the so-called *pons*, and the large masses of fibres called crura uniting the pons to the hemispheres of the brain; here also may be seen all the cerebral or cranial nerves, as they proceed to or from the brain; the large arteries likewise, which all reach the cerebral portion of the encephalon by the base. The two little rounded eminences seen here are called mammillary eminences.

The grey matter of the brain is found chiefly on the surface, and the white, medullary or fibrous in the interior, but not uniformly so. The ventricles of the brain (Fig. 65) all communicate with each other, directly or indirectly.

§ 187. The cerebellum is placed under the posterior part of the brain, and is separated from it by the tentorium, a partition formed by the dura mater. It also is composed of two hemispheres, and a mesial portion connecting them together. On the surface of the cerebellum there are no convolutions, but the margins of laminæ or plates, of which the cerebellum is composed. It is connected with the medulla spinalis, the pons, and cerebrum by peduncles of medullary fibres called crura. In volume it is about one-third of the cerebrum, and is larger comparatively in the child than in the adult.

§ 188. *Optic Lobes.*—By removing the upper portion of the hemispheres and the corpus callosum, the ventricles of the brain are exposed; also certain rounded masses, forming as it were the base of the section. These masses, named in succession from before backwards, are the corpora striata, the thalami nervorum opticorum, and the tubercula quadrigemina; and on the back and somewhat lower part of the thalami may be seen, by raising the thalami upward, certain rounded elevations of a greyish colour; these are the corpora geniculata. On all these structures important experiments have been made in living animals.

§ 189. *Spinal Marrow; Medulla Spinalis.*—The medulla spinalis (Fig. 64 *c*; Fig. 66 *f*), may be viewed as a continuation of the medulla oblongata and that of the brain itself. A median fissure of no great depth divides it into two lateral portions, anteriorly and posteriorly. Its upper extremity, which is enlarged, is usually called the bulb, by others the medulla oblongata: here are to be seen various swellings called olivary, pyramidal, and restiform bodies; and at the sides of this medulla oblongata and of the spinal marrow following it, may be seen proceeding outwards the spinal nerves. No nerves come from or go to the cerebrum proper, unless it be the olfactory. Where the nerves leave the spinal marrow to proceed to the pectoral extremities, the organ is usually enlarged; and the same occurs, but not so distinctly, lower down, where the nerves leave to proceed to the pelvic extremities. In man, the spinal marrow descends only as low as the second lumbar vertebra, terminating in a fine thread-like body, by which it is attached to the lower part of the column. The inferior portion of the

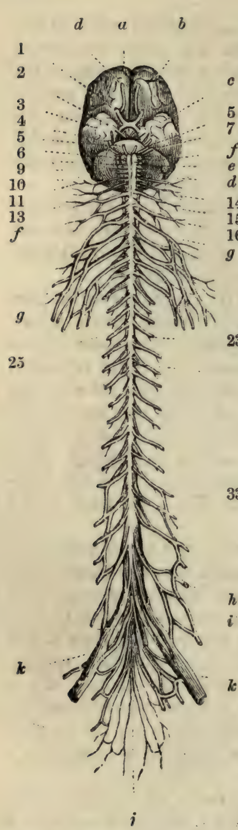

Fig. 66. Cerebro-spinal Axis.*

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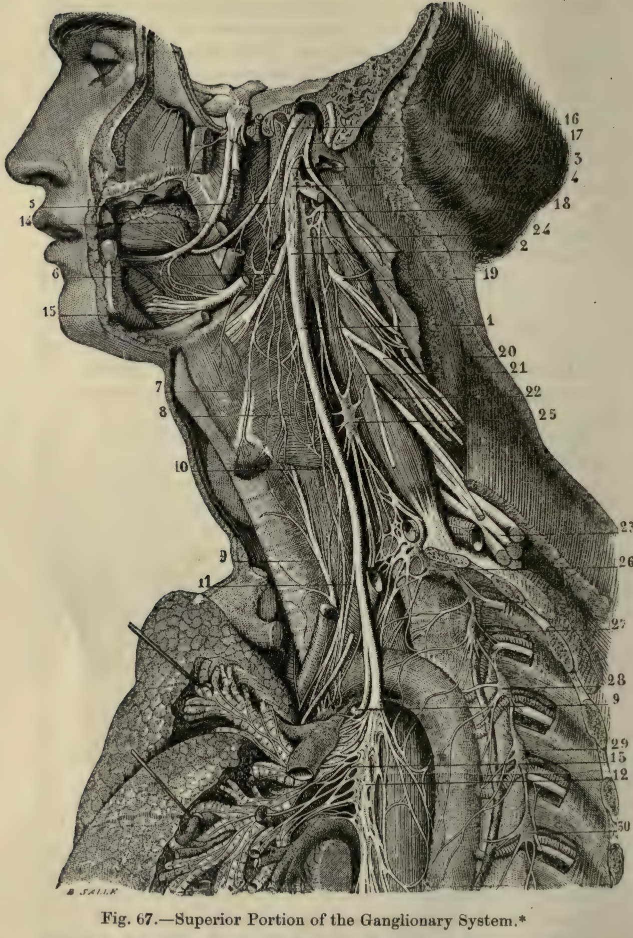
* The cerebro-spinal axis seen anteriorly: the nerves have been cut through at a short distance from their origin or *central termination*:—*a*, the cerebrum; *b*, anterior lobe of the left hemisphere of the brain; *c*, middle lobe; *d*, posterior lobe, almost concealed by the cerebellum; *e*, the cerebellum; *f*, the medulla oblongata or bulb; 1, first, or olfactory pair of nerves; 2, second pair, or optic; 3, third pair, or motores oculorum, 4, fourth pair, or pathetic; 5, the facial, or fifth pair: 6, sixth pair, or abducentes; 7, nerves of the seventh pair, or facial; also the acoustic or portio mollis, by some called the auditory, and viewed as a division of the seventh; others call them the eighth pair; 9, the glosso-pharyngeal nerves, called the ninth pair by some, by others the anterior division of the eighth pair; 10, the pneumogastric, by some included in the eighth pair, by others called the tenth pair; 11, nerves of the eleventh and twelfth pairs, the first being viewed by some as a division of the eighth pair, and called spinal accessory; the latter, called by some the ninth, by others the twelfth, is the motor nerve of the tongue; 13, nerves of the thirteenth pair, or sub-occipital; 14, 15, 16, the first, second, and third pairs of cervical nerves; *g*, cervical nerves forming the brachial plexus; 25, one of the pairs of nerves of the dorsal portion of the spinal marrow; 33, one of the pairs of lumbar nerves; *h*, lumbar and sacral nerves forming the plexus whence come the nerves of the lower extremities; *i* and *j*, termination of the spinal marrow, called *cauda equina*; *k*, great sciatic nerve proceeding to the lower extremities.

spinal canal, lumbar, sacral, and coccygeal (where it is quite imperfect), is occupied with the membranes and by the nerves proceeding from the spinal marrow. This assemblage of nerves within the canal was called by the older anatomists the cauda equina, in the centre of which will be found the terminating filum or thread of the organ itself.

The spinal marrow is composed, like the brain and cerebellum, of a medullary and cineritious portion; but here the grey matter is central and the medullary external. A fluid, clear and limpid, discovered by Cotunni, a distinguished Neapolitan physician, fills up the space intervening between the arachnoid membrane and the pia mater, by means of which, no doubt, this extremely delicate organ is protected from shocks and other injuries.

§ 190. *Structure of the Encephalon.*—The organ is composed of two distinct substances, the cineritious and medullary; this latter is fibrous, and to the tracing its fibres anatomists have in all ages given the greatest attention.

By commencing with the spinal marrow, and tracing its fibres upwards, it will be found that it is composed of two halves, united to each other by transverse medullary fibres. These halves are each composed of six medullary bands or columns, of which four occupy the anterior surface, two the posterior. The four anterior ones may be traced upwards into the corresponding pyramidal and olivary bodies, proceeding from thence into the brain itself; the two posterior proceed, we shall find, to the cerebellum. To return to the olivary and pyramidal fasciculi: we observe, first, that a portion of those on the right side cross to the left, and those from the left to the right column, thus decussating with each other. After this decussation, they plunge into the annular protuberance (pons Varolii), and, continued forwards, constitute the crura cerebri. The fibres from these ultimately expand in the convolutions of the anterior and middle lobes of the brain. The longitudinal fibres of the olivary fasciculi ascend like those of the pyramids, and passing through the pons form the inner and posterior parts of the peduncles of the brain; during their course they traverse several masses of the cineritious substance, increase in size, and finally pass into or form various parts of the brain, as the thalami optici and corpora striata; finally, they expand into the cerebral convolutions. Several transverse commissures, as the corpus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B. SALLE

Fig. 67.—Superior Portion of the Ganglionary System.*

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* This wood engraving, copied from M. Sappey's *Treatise on Human Anatomy*, represents the principal nerves of the neck, as well as the ganglions

callosum, and anterior and posterior commissures, connect the two sides of the brain with each other.

The posterior columns of the medulla oblongata (restiform bodies) unite with some fibres coming from the neighbouring portions of the medulla spinalis, and thus constitute the crura cerebelli, or crura ad medullam oblongatam; these fibres plunge into the centre of the cerebellar hemispheres, and assist in forming the central medullary mass, which being invested with cineritious matter, forms that remarkable assemblage of laminæ to which anatomists give the name of arbor vitæ, seen on making a section of either hemisphere of the cerebellum. Thus the cerebellum receives crura or peduncles from three sources, viz., the pons, the medulla oblongata, and the tubercula quadrigemina.

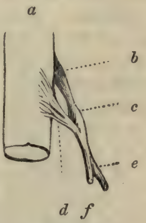

Fig. 66A.*

§ 191. *Nerves.*—The nerves originating, or as some view it, terminating, in the encephalon, amount to forty-three pairs (see Fig. 64 and Fig. 66); they are reckoned numerically from before backwards. The first twelve pairs arise within the cranium, and leave the cavity by apertures in the cranial bones; the thirty-one pairs which follow arise from the spinal marrow, and leave the osseous canal by openings called intervertebral, as being placed between the vertebræ.

Each of these pairs of nerves is formed of a great number of filaments, enclosed in a *neurilemma.* These elementary fibres are extremely fine; they do not unite with each other, but pass from the central extremity of the nerve to the peri-

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of the neck and thorax belonging to the sympathetic system of nerves.—1, pneumogastric nerve, the principal branches of which form plexuses with the great sympathetic, to supply the lungs, heart, stomach, &c.; 6, 7, branches of the pneumogastric, supplying the larynx; 9, 9, recurrent nerve, a branch of the pneumogastric ascending from the base of the neck to the larynx; 10, 11, cardiac branches proceeding to the heart; 13, pulmonary plexus; 14, lingual nerve; 15, terminal portion of the great hypoglossal; 16, glosso-pharyngeal nerve; 17, spinal accessory of Willis; 18, cervical nerve of the second pair of spinal nerves; 19, third cervical pair; 23, 26, 27, 28, pairs of cervical nerves, uniting with the first dorsal to form the brachial plexus; 24, superior cervical ganglion of the great sympathetic; 25, middle cervical ganglion; 26, inferior cervical ganglion; 27 to 30, dorsal ganglions.

* A portion of the spinal marrow.—*a*, medulla spinalis; *b*, posterior root of one of the nerves; *c*, ganglion situated on this root; *d*, anterior root of the same nerve, about to unite with the posterior root after this latter has passed the ganglion; *e*, common trunk formed by both roots; *f*, small branch proceeding to anastomose with the great sympathetic.

pheral. At their origin, the fibres composing the nerve are called roots, and are grouped in the spinal nerves into anterior and posterior roots.

On the posterior root is a ganglion through which the filaments pass, and then unite with the anterior root. On certain of the cranial nerves, some of the roots also have ganglions. Experiment has shown that the posterior roots are nerves of sensation; the anterior, nerves of motion: when nerves unite with each other by what is called anastomosis* (although they do not really unite, but merely exchange fibres), there results what is called a plexus.† Finally, in the various organs the nerves seem to terminate by forming wide plexuses or loops.

§ 192. *Ganglionary System.*—This system—which has also been called the nervous system of organic life, the system of the great sympathetic, &c.—is composed of a certain number of small masses of nervous matter, united to each other by filaments of communication, and by the same means to the nerves of the cerebro-spinal system. From these ganglions, nerves proceed to numerous vital organs, and are supposed also to follow the course of all the great blood-vessels.

The ganglions composing this system are arranged in a double column on each side the spine, anteriorly, from the first vertebra to the last; but many others are scattered through the viscera. They are not found in the limbs. A broad distinction which exists between the cerebro-spinal nerves and the ganglionary is, that the former proceed to the skin, organs of sense, muscles, &c.; the latter to the vital organs, as the heart, intestines, liver, kidneys, &c.: the former are nerves of relation; the latter have more a reference to nutrition.

§ 193. *Nervous System of other Animals.*—In all animals, birds, fishes, and reptiles, the arrangements of the nervous system are much as in man.

But in the *invertebrata* it is not so; in these the cerebro-spinal axis seems wanting, and all the nerves of the body seem to reunite in certain ganglions more or less apart from each other (Fig. 68). Finally, in the great division of the zoophytes, there remains only a vestige of a rudimentary nervous system, and even this seems to be occasionally entirely absent. In speaking of these various groups of animals, the peculiarities here adverted to will be noticed.

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* It is not then a true anastomosis.

† Plexus, from *plecto* (I intermingle) is a term applied also to the blood-vessels, and means merely a sort of network.

Let us now consider the functions of the system.

§ 194. Sensibility is the faculty to receive impressions, and to have a consciousness of them. It belongs to all animals, but in different degrees. As we ascend in the zoological scale, the sensations become more and more varied, the knowledge acquired through them greater, the nervous system more complex.

§ 195. In the lowest class of animals, the structure is at first very simple, and their sensations do not seem very distinct. In the earth-worm, a knotted cord extends throughout the whole length of the body, and to and from these knots or ganglions the nerves proceed; but each of these parts seems equal to every other, and there is no specialization of any. This simplicity of structure gives way to a form more complex as we ascend in the animal scale.

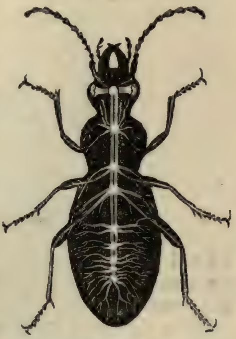

Fig. 68.—Nervous System of an Insect (Carabus of the gardens). A Beetle.

§ 196. *Functions of the Nerves.*—All parts of the body are not equally supplied with nerves, and there are parts which seem to have none. Hence, no doubt, is the fact that whilst some parts are extremely sensitive, others are but little so, or wholly insensible. No experiments are required to show that a part owes its sensibility to the contiguity of the nerve which connects it with the central organs of the nervous system. The nerves, then, are not the organs by which the sensations are perceived; they merely transmit them to the central system, where all perception resides.*

§ 197. Where, then, is the seat of the faculty of perception? Which is the perceiving organ?

§ 198. *Influence of the Encephalon.*—Does perception reside in the spinal marrow, the cerebellum, or the cerebrum?

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* It is now certain that perceptions or impressions on the central organs of the nervous system are of two kinds; one attended with consciousness, the other without.—R. K.

Experiments on living animals, surgical operations, and accidents, have repeatedly proved that the seat of perception is not in the spinal marrow. The cutting this across in a living animal merely destroys the sensibility, and paralyzes the movements of all the parts supplied with nerves from it below the point divided.

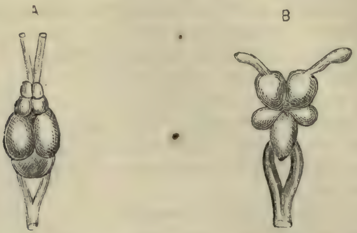

Fig. 69.—A, Brain of the Cod. B, Brain of the Shark.

With the brain it is quite otherwise. The surface of the brain and its substance generally, may be cut or irritated in a living animal without it being sensible of any injury or pain; but remove it, and the whole body of the animal instantly becomes insensible. The action of the brain is as essential in the perception of sensations as for the acts of volition.

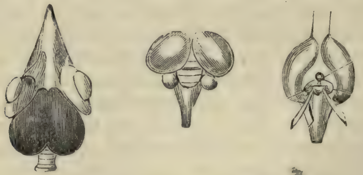

Fig. 70.—Brain of the Sparrow.

§ 199. The insensibility of the brain when cut or rudely touched is a remarkable circumstance, long known, however, to surgeons. But the faculty of perceiving sensations caused by impressions on the organs resides in it; and it would seem, from Flourens' experiments, to reside more especially in the hemispheres of the cerebrum, to which the sensations are transmitted by the nerves.

§ 200. Neither ought it to be forgotten that each nervous fibril is quite distinct from one extremity to another; and to this must be ascribed the distinctness in our sensations, and the referring them always to their peripheral extremities. After amputation, the pains which occasionally continue are constantly referred to the foot or hand which is no longer present.

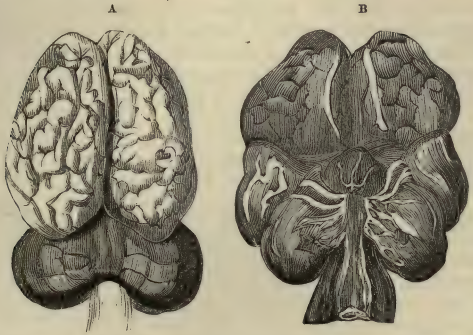

Fig. 71.—Brain of the Rorqual (Balænoptera rorqual). Figure A gives the upper surface; figure B the lower.

§ 201. *Nerves of Sensibility or Sensation.*—All nerves have not the power of transmitting sensations to the brain; some, on the contrary, are clearly nerves of motion, whether acted on by our will or excited by other means. Some nerves, as the optic, transmit only the impressions received from colours; to other stimulants this nerve is insensible.

§ 202. *Modifications of the Sensibility.*—To these modifications of the sensibility we owe the *five senses;* the senses of touch, taste, smell, hearing, seeing, are so many distinct faculties putting us in relation with the various qualities of the external world. To the first pair of nerves belongs the sense of odours; by the second pair we perceive coloured bodies; the portio mollis of the seventh pair, by some called the eighth pair, is the instrument by which the sensation of sounds is conveyed to the brain; and by means of a branch of the fifth pair we perceive the sapid qualities of objects; whilst the spinal nerves distributed to the fingers and toes, endow their extremities with fine tactile powers.

§ 203. The roots of the spinal nerves being double, a double function had been long suspected; this was put beyond dispute by Bell and Magendie,* who showed that by the posterior roots the sensations travel to the brain, whilst by the anterior the power of motion travels to the muscles. Some differences have been observed in various parts of the spinal marrow; the sensibility is acute in the dorsal aspect of the organ, and much more feeble anteriorly.

[Some recent experiments performed by M. Brown-Séquard raise doubts as to the correctness of this view when taken too exclusively, but they do not affect the chief results.—R. K.]

§ 204. *Ganglionary System.*—This system is but little, if at all, sensible to ordinary stimulants: neither cutting nor pinching affects it. In the healthy state, the organs to which the nerves of this system proceed are in like manner but little, if at all, sensible; but when diseased, their sensibilities become highly exalted.

§ 205. *Special Organs of the Senses.*—The apparatus of the sensibility is not composed only of the different parts of the nervous system whose uses we have already pointed out; the nerves furnished with the faculty of transmitting to the brain the sensations reaching us from without, do not terminate freely in the exterior, so as to receive directly the contact of the producing agents of our sensations, but terminate in positive instruments destined to collect, so to say, the excitation, and to prepare it in such a way as to assure its action. These instruments are the organs of the senses, and it is essentially by the intermedium of these organs that the sensations reach us; but they are not indispensable for the exercise of all these faculties: the tactile sensibility may be called into play everywhere where nerves exist adapted to conduct the ordinary sensations, and it is only by the special senses, that is to say, by the taste, smell, hearing, and sight, that this intermediate organ between the nerve and the external world is a necessary condition.

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* First by Mr. A. Walker.—R. K.

Having studied in a general way the phenomenon of the sensibility, as well as the organs which are its seat, we ought now to examine more in detail each of the forms under which this property is manifested, or in other words, enter on the particular history of each of the senses with which nature has endowed animals.

OF THE SENSE OF TOUCH.

§ 206. All animals possess a tactile sensibility more or less delicate, and it is especially by the intermedium of the membrane with which the surface of their bodies is covered that this faculty is exercised. To study it, it is, then, above all necessary to examine what is the structure of the skin.

In man, the external surface of the body, and that of the cavities hollowed out in the interior, but communicating externally, such as the digestive canal, &c., are clothed with a tegumentary membrane more or less thick, and quite distinct from the parts which it covers. This membrane is everywhere continuous with itself, and in reality it forms but a continuous whole; but its properties are not everywhere the same, and it is called by different names when it is reflected internally to line the interior cavities, or when it is extended over the outer surface of the body. The internal portion of the general tegumentary membrane is called *mucous membrane*, and the external portion *skin*.

§ 207. *Structure of the Skin.*—Two principal layers compose the skin: the dermis or true skin, and the epidermis or scarf skin.

The dermis forms the deeper and thicker layer of the integuments. It is a strong, supple, elastic membrane, whitish, and very resistant. A great number of fibres may be seen in it, crossing each other in all directions. Beneath it is a dense layer of cellular substance connecting it to the subjacent parts, and in this sometimes fleshy fibres are found. On its surface may be seen, especially in the palms of the hands and extremities of the fingers, the elevations, called papillæ, arranged in regular rows. Of the dermis of animals leather is made.

The epidermis is a kind of insensible varnish laid over the sensitive skin beneath. It is a tissue composed of dried-up utricles, which form on the surface of the dermis, and which harden only by being exposed to the air. It is composed of several layers, of which the lower or deepest layer, being soft and containing the pigmentary matter giving the colour to the skin, has been viewed and described by some physiologists as a distinct membrane, under the name of *rete mucosum.* In man, and in many animals resembling him, the epidermis is cast off in the form of small scales, which are constantly renewed. In serpents, the entire epidermis is cast off as a slough.

The pores of the skin correspond to the summits of the papillæ just described. They give passage to the perspiration or sweat, an acid liquid formed by secretion, and which must not be confounded with the insensible perspiration. These pores, exceedingly minute, do not traverse the skin; they are merely the orifices of the excretory canals of so many small ampullæ lodged in the substance of the skin, and which are the secreting organs of the sweat.

Other larger orifices are found on the surface of the skin; some for the passage of the hairs, and others for the escape of a fatty matter secreted by follicles lodged in the substance of the skin. These are called sebaceous glands or follicles.

§ 208. The principal use of the epidermis is to throw obstacles in the way of evaporation, and to protect the sensitive skin beneath. It deadens more or less all impressions, and hence its thickness on the heel and sole of the foot generally: it thickens whenever it is exposed to friction. Finally, in some animals it becomes encrusted with calcareous matters, becoming then altogether inflexible, and rendering the surface of the body insensible.

§ 209. The sensibility of the skin resides in the dermis and depends on the nerves of touch distributed to the papillæ.

§ 210. *Special Organs of Touch.*—Tactile sensibility is spread over the whole body, but it is in the extremity of the fingers alone that the true power of touch resides. The hand, of course, is especially made for the exercise of this faculty. The delicacy of the integuments, the length of the fingers, and the opposing thumb, all contribute to this effect.

In most animals these organs are not so favourably arranged: nevertheless, the proboscis of the elephant is a wonderful tactile instrument. There are animals which employ the tongue for this purpose, and others are provided with palpi, tentacula, &c. (Figs. 9, 10).

§ 211. By touch we appreciate most of the physical properties of bodies, such as their dimensions, form, temperature, consistence, polish or the opposite, weight, movements, &c. Some philosophers have adopted exaggerated ideas of the importance of this sense to human intelligence, for which there is not the slightest occasion.

OF THE SENSE OF TASTE.

§ 212. By this sense we discover the savours of bodies.

§ 213. Certain bodies are extremely sapid, others but little, and some not at all. The cause of these differences is quite unknown; but, generally speaking, insoluble bodies are not sapid, and when the tongue is dry and parched the taste is not perceived.

§ 214. By taste most animals distinguish their food; and hence, no doubt, the reason why the instrument is placed at the entrance of the digestive tube. The tongue is the principal seat of taste; but other parts of the mouth possess the power of perceiving certain savours. The mucous membrane which covers the tongue of man is sufficiently well supplied with bloodvessels and nerves supplying papillæ of various forms—lenticular, fungiform, and conical. The tongue itself is muscular, and receives branches of motor and sentient nerves. A branch of the fifth pair is the gustatory; it is sometimes called lingual.

§ 215. If this nerve be cut in the living animal, the sense of taste is destroyed, but the movements of the tongue remain; if divided within the cranium, the sense of taste is destroyed all over the interior of the mouth.

The section of the hypoglossal nerves destroys the motion of the tongue and of all other parts to which these nerves proceed. The sense of taste remains unaffected. The glossopharyngeal, distributed chiefly to the pharynx, and which are sensitive nerves, have also some gustatory powers.

§ 216. The tongue has nearly the same structure in all animals; but in birds it is generally cartilaginous, and without nervous papillæ; accordingly, their sense of taste is considered as obscure. It is much the same in fishes; and in the lower animals, the faculty seems to be exercised by all the interior of the mouth.

OF THE SENSE OF SMELL.

§ 217. Odours are produced by particles of extreme tenuity, which escape from odorous bodies, and spread through the air like vapours. The quantity requisite of some of these odorous matters powerfully to affect the smell is extremely small: a morsel of musk, for example, will perfume the air of a room for a considerable time without losing its weight. Some bodies imbibe vapours and become odorous in their turn, such as clothes and water; but others resist their passage altogether, such as glass. Odours may be perceived at a great distance, but the odorous particles must always come in contact with the organs. For this, the mechanism of smell is analogous to that of taste and touch, whilst in sight and hearing it is quite otherwise.

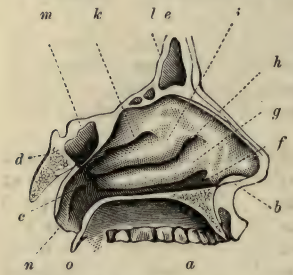

Fig. 72.—Nasal Fossæ in Man.*

§ 218. As the air is the ordinary vehicle of odours, the organ perceiving them is placed at the entrance of the respiratory tubes. In man, as well as in mammals, birds, and reptiles, the nasal fossæ are the seat of the sense of smell.

§ 219. These fossæ communicate with the exterior by the nostrils, and open behind into the pharynx. They are separated from each other by a vertical partition: their walls are formed by various bones of the face, and by the cartilages of the nose. On the external wall of each may be seen three prominent laminæ, curved on themselves;† they are formed by the turbinated bones; and by being rolled on themselves they thus extend considerably the pituitary membrane, which invests them. Upon this membrane the olfactory nerves are distributed. Finally, between these turbinated bones there are longitudinal grooves, called meatuses. These fossæ communicate with cavities, called sinuses, hollowed out in the thickness of the frontal bone, the superior maxillary, &c. The pituitary membrane is thick, and has a velvety appearance; on its surface may be observed a vibratile movement, produced by microscopic cilia; finally, it is continually moistened by a viscous liquid, called nasal mucus, and it receives many nervous filaments from the olfactory and fifth pair of nerves.

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* Vertical section of the nasal fossæ, representing the outer wall of the left nasal fossa.—*a*, the mouth; *d*, portion of the base of the cranium; *e*, forehead; *m*, sphenoidal sinus; *n*, opening of the Eustachian tube; *o*, pendulous palate. The frontal sinuses do not exist in young persons, but with age they often acquire considerable dimensions, as do the sphenoidal sinuses. They are generally small in women.

† That is, twisted in a spiral manner, like a univalve shell.

§ 220. The membrane must be moist, in order that odours may be perceived; and the sense is strongest in the upper part of the nostril. The extent of membrane seems greatly to influence the power of the organ; and in this respect the carnivora, the ruminants, and some pachydermata, are remarkable for the development of the turbinated bones, and consequently for the extent of mucous membrane covering them. In reptiles the organ is extremely simple.

§ 221. In fishes, the nasal fossæ do not communicate with the pharynx, but are merely cavities shut in at the back, and the pituitary membrane presents in them a number of folds, arranged like rays around a central point, or in parallel rows like the teeth of a comb, on each side of a median band.

But there are many animals which have a fine sense of smell, as insects, crustacea, and mollusca, and in which no special organ of smell has ever been discovered.

OF THE SENSE OF HEARING.

§ 222. The apparatus of hearing is very complex, minute, and difficult to describe, and its essential part is enclosed within the petrous portion of the temporal bone (Fig. 73 *e*).

We divide the ear of man into three portions—the external ear, the middle ear, and the internal ear. The external ear is composed of the *pavillon* or figured part of the ear, and the auditory canal.

The figured part of the ear is composed of a fibro-cartilaginous lamina, adhering to the edge of the auditory canal, and covered with a very fine and thin skin, dry and tense, and is so arranged as to form an acoustic tube. The lobe of the ear is not supported by any cartilage. The auditory tube is partly cartilaginous and partly osseous; the integuments pass into it, and terminate by a cul-de-sac over the drum of the ear. It is in this tube or canal that we find the small sebaceous follicles which secrete the cerumen—that is, the wax of the ear.

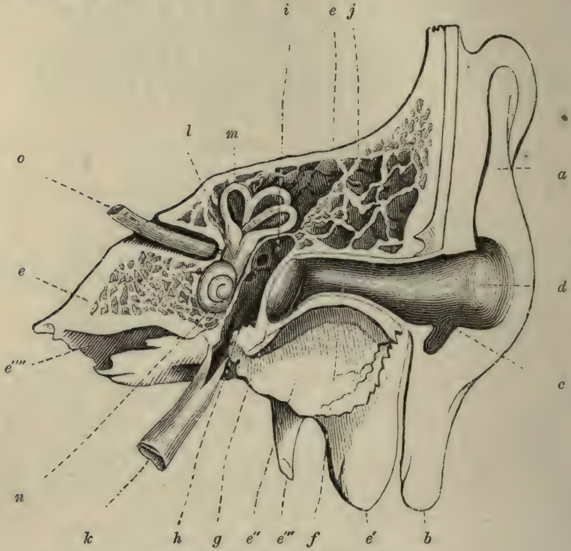

Fig. 73.—Auditory Apparatus in Man.*

The middle ear is composed of the tympanum, of the cavity of the tympanum, and parts connected with it.

The cavity of the tympanum is a cavity of an irregular form, hollowed out in the substance of the petrous part of the temporal bone, and separated from the auditory canal by the membrane of the tympanum. Opposite to this membrane are two

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* Vertical section of the auditory apparatus, somewhat magnified as respects the deeper structures.—*a*, external ear; *b*, lobe of the ear; *c*, the eminence called antitragus; *d*, concha, continuous with the external auditory canal (*f*); *ee*, petrous part of the temporal bone; e', mastoid process; e'', articular or glenoid cavity for the condyle of the lower jaw; e''', styloid process of the temporal bone; e'''', extremity of the canal by which the internal carotid artery passes into the interior of the cranium; *f*, auricular canal; *g*, membrana tympani; *h*, cavity of the tympanum; the ossicula auditus have been removed; *i*, opening in the wall of the tympanum leading to osseous cells; the fenestra ovalis and rotunda are close to this opening: *k*, Eustachian tube; *l*, vestibule; *m*, semicircular canals; *n*, cochlea; *o*, acoustic nerve.

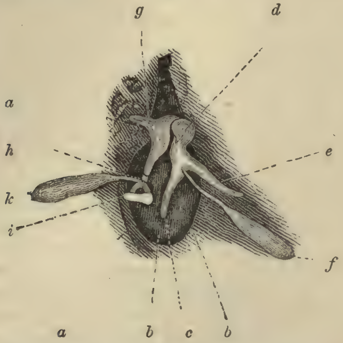

Fig. 74.—Tympanum and Ossicula Auditus.*

openings, called the fenestra ovalis and fenestra rotunda. In the back wall of the cavity is an opening leading to the mastoid cells; and inferiorly may be seen the opening of the Eustachian tube, leading to the nasal fossæ, and thus admitting the external air into the cavities of the middle ear. Finally, this cavity is traversed by a chain of small bones, extending from the drum of the ear to the bottom of the fenestra ovalis, where it touches by the base of the stapes the membranous vestibule.

The bones are four in number, and are called the malleus, incus, lenticular bone, and stapes. A small stalk belonging to the malleus rests on the drum of the ear. Finally, small muscles attached to these bones augment or diminish the tension of the chain.

The internal ear is also enclosed within the petrous part of the temporal bone. It is composed of three parts: the vestibule, the semicircular canals, and cochlea. The vestibule is in the middle, and communicates with the tympanum by the fenestra ovalis. The semicircular canals (*m*) are three in number, and are rounded osseous and membranous tubes. Finally, the cochlea (*n*) is a single organ, resembling the shell of the whelk; its cavity is divided into two parts by a longitudinal partition, half osseous, half membranous, and communicates with the interior of the vestibule and with the tympanum by the fenestra rotunda. The internal ear is osseous and membranous, containing a watery fluid, and, even in man, some remains of a semi-solid body, analogous to the vitrine of the eye. The auditory nerve enters the petrous part of the temporal by the internal auditory canal, and terminates in the interior of the membranous pouches of the vestibule, semicircular canals, and cochlea. On its integrity depends the sense of hearing.

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* Represents the cavity of the tympanum, the ossicula auditus, and their muscles, magnified.—*a a*, cavity of the tympanum; *b*, membrana tympani, or rather the osseous circle to which it is attached; *c*, handle of the malleus, resting on the middle of the membrana tympani; *d*, head of the malleus articulating with the incus; *e*, long handle of the malleus, passing into the glenoidal fissure; the anterior muscle of the malleus is attached to it; *f*, internal muscle of the malleus; *g*, anvil; *h*, lenticular bone; *i*, stapes; *k*, musculus stapedius.

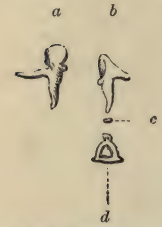

Fig.75.—Small Bones of the Ear.*

§ 223. *Mechanism of Hearing.*—Sound is the result of a very rapid vibratory movement which the particles of sonorous bodies experience when struck. The undulations of the sonorous body are communicated to the air which is in contact with it, and are thus propagated to a distance. To be audible, they must reach the fluid which immediately bathes the acoustic nerve.

§ 224. The sonorous vibrations first strike the external ear; by it they are reflected and strengthened, and directed towards the middle ear by the auditory passage; but in man, probably from the smallness of the external ear, the loss of it does not greatly affect the hearing. The vibrations excited in the external ear pass internally by the walls of the canal, but chiefly through the air which fills the canal, and so reach the middle ear.

§ 225. The membrane of the tympanum is the chief agent in facilitating the transmission of the sonorous vibrations of the external air towards the acoustic nerve; this has been proved by many experiments.

§ 226. The vibrations are transmitted from the membrane of the tympanum to the small bones of the ear, to the walls of the cavity, and to the air it contains, and thus they reach membranes stretched over apertures leading to the internal ear. Now the posterior surface of these membranes is in contact with the aqueous liquid filling the internal ear, and in this liquid are suspended the membranous pouches, which, in their turn, are filled with another liquid, into which plunge the terminating filaments of the acoustic nerve. Thus the vibrations reach the nerve itself by which the sensation is communicated to the brain.

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* *a*, the malleus; *b*, the incus; *c*, the lenticular bone; *d*, the stapes.

§ 227. The air contained in the cavity of the tympanum seems to play an important part in the phenomena of hearing, for it has been observed that when the Eustachian tube has been closed by disease, deafness is almost sure to follow. But the integrity of the drum of the ear is not so essential for the due performance of the function.

§ 228. However important the chain of small bones of the tympanum may be in moderating the intensity of sounds striking the drum of the ear, or by assisting in its tension so as to enable us to perceive remote or feeble sounds, certain it is that the loss of the hammer, the anvil, and lenticular bone does not necessarily cause the loss of hearing, which however is said to be sure to happen when the stapes has also been lost.

§ 229. Admitting that all the parts just described serve to perfect the ear of man, it must also be admitted that they are not all essential to the organ as an instrument of sense. They also gradually disappear as we descend the scale of beings. Thus, in birds, we have no longer an external ear. In reptiles the external auditory canal also disappears; the drum of the ear becomes external, and the cavity of the tympanum simplified; finally, in most fishes every vestige of an external ear and a middle ear disappears, and the apparatus of hearing is composed of a membranous vestibule, surmounted by three semicircular canals, furnished below with a small sac, which seems to represent the cochlea, the whole being suspended in the lateral part of the great cavity of the cranium.

In animals placed still lower in the scale, we find, also disappearing, the cochlea and semicircular canals, the structures of which we know not the use;* but the membranous vestibule is an organ which is never wanting in any ear. A membranous sac filled with a fluid, into which penetrate the nerves of hearing, is the essential of the organ. In this fluid are suspended some solid corpuscles which oscillate incessantly, and which may be compared to the otolites of the internal ear in fishes.

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* According to the experiments of M. Flourens, it would seem that the destruction of the semicircular canals does not destroy the hearing, but renders it painful and confused.

In most insects there is no vestige to be found of the organ of hearing, and yet those animals do not seem insensible to sound. Finally, in zoophytes, and in animals still lower, the faculty of hearing itself appears to be wanting.

OF THE SENSE OF SIGHT.

§ 230. The sense of sight enables us to discover the presence of objects by their colours. It takes cognizance also of their form, size, and relative position to us. The optic nerve, the eyeball and its appendages, constitute the apparatus.

§ 231. *Structure of the Eye.*—The globe of the eye is a hollow sphere, composed of membranes, and humours more or less fluid. When the globe of the eye is dissected from without inwards, it is found to be composed of the tunic, called *sclerotic*, white and fibrous, and of great strength. In front, and continuous with this, is the translucent cornea, by which the rays of light pass into the interior of the eye. If the cornea be opened, the aqueous humour escapes. By removing the cornea, or a large portion of it, we expose the iris, a coloured circular membrane, placed like a partition between the anterior and posterior chambers of the aqueous humours. The iris floats in this humour, is contractile, and by its contractility the aperture in its centre, called the pupil, and which in man is circular, varies perpetually with the amount of light to which the eye is exposed. This circular membrane is muscular, or at least fibrous and contractile, and is abundantly supplied with nerves.

Continuous with the iris, and extending backwards beneath the sclerotic, is the dark vascular membrane, called choroid, connected with the pigment of the eye; and within it the retina, or membrane in which the optic nerve terminates.

The humours which these membranes contain and circumscribe are in succession, proceeding from before backwards, the aqueous humour, the lens, and the vitreous humour.

The optic nerve enters the eyeball towards the back part, passing through the sclerotic and choroid, and terminates in the retina, which is generally viewed as an expansion of this nerve. But other nerves enter the eyeball, such as the ciliary, coming partly from the fifth pair and partly from a ganglion, the ophthalmic, with which the fifth and third communicate. From this ganglion, though small, most of the ciliary nerves proceed into the interior of the eye to supply the ciliary circle and the iris.

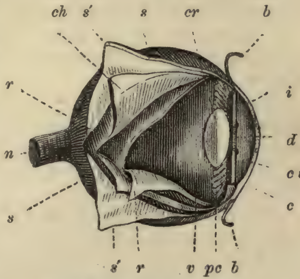

Fig. 76.—Globe of the Eye Dissected.*

The ciliary ligament or circle is a peculiar ring connecting the choroid, iris, and sclerotic to each other. Its nature and functions have not yet been determined, but it is well supplied with nerves in animals of strong vision, as in the eagle and vulture.

[An extended series of inquiries into the structure of the ciliary ligament, or body, induced me, many years ago, to believe it to be of the same structure as the iris, and to assign to it the functions of the adaptation of the eye to various distances. See "Trans. Roy. Soc. of Edin.," 1827.—R. K.]

The humours are colourless and transparent, and the same remark applies to all the parts situated between the exterior and the retina in the axis of vision, or measured by the size of the pupil. The cornea is everywhere absolutely transparent, and so is the conjunctiva which covers it.

In the iris, some of the fibres proceed like radii from the free edge of the pupil towards the base: others surround, as it were, the pupil, and act like a sphincter in contracting the orifice. The aqueous humour, though quite transparent, contains a little albumen and salts, such as are met with in all animal secretions. When suffered to escape by a puncture or section of the cornea, it is speedily replaced. The ciliary processes seen surrounding the capsule of the lens, and which are appendages of the choroid membrane, are extremely vascular, and may be the source of the secretion of this humour and of the vitrine.

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* *c*, the transparent cornea; *s*, sclerotic; *s'*, portion of the sclerotic turned back to display portions of the membranes situated beneath it; *ch*, the choroid; *v*, the retina; *n*, the optic nerve; *ca*, anterior chamber of the eye, situated between the cornea and the iris, and communicating with the posterior chamber by the opening in the iris called the pupil; these chambers contain the aqueous humour; *i*, the iris; *p*, the pupil, an opening in the iris by which the rays of light pass into the deeper chambers of the eye; *cr*, the crystalline humour or lens; *pc*, ciliary processes; *v*, vitreous humour; *b b*, a portion of the conjunctiva.

The crystalline humour or lens is a body of considerable density, composed of concentric layers. It is enveloped in a distinct capsule, and when removed in young animals may be replaced by another. The lens is more convex posteriorly than anteriorly in man.

The vitrine (vitreous humour) is a semi-solid body, enclosed in a capsule, intersected by membranous partitions, in which the fluid is contained. Its membrane is called the hyaloid.

In albinos, the pigment, an appendage of the choroid and iris, is wanting.

Under a high microscope, the filaments of the optic nerve seem to terminate in numerous cylindrical papillæ, resembling mosaic.

§ 232. *Mechanism of Vision.*—The sun and bodies in a state of ignition are visible in themselves; but other bodies are visible to us only by the reflection of light in such a way as to reach us.

Light moves with extreme rapidity; it affects us only when it reaches the retina; opaque bodies reflect or absorb it; transparent bodies, as air, offer it a free passage.

Whatever obstructs the free passage of the light through the conjunctiva, cornea, and humours of the eye, in its way to the retina, obstructs or destroys vision; hence the effects of opacity of any of these structures: the cataract which destroys vision is merely an opaque lens, which being removed out of the axis of vision by the surgeon, restores the function of the eye.

But these diaphanous parts of the eye serve other purposes besides the negative one of permitting the free passage of the rays of light into the interior of the eyeball; they change the direction of the rays of light. The eye is but a kind of *camera obscura*, the image of objects being as it were painted on the retina; this image we see, and not the object itself.

To understand this part of the history of vision, it is only necessary to refer briefly to some of the laws of optics.

Light travels in straight diverging lines. When they fall perpendicularly on the surface of a transparent body, they traverse it without any change in their direction; but falling obliquely, they are always affected more or less in their direction. If they are passing from a rarer into a denser medium, as from air into water, they are refracted towards the perpendicular; the opposite happens in passing from a denser into a rarer medium; they are then refracted from the perpendicular. A straight rod, for example, plunged into water, appears bent at the point of immersion; and by placing a coin in an empty basin (Fig. 77 *a*), so that it shall be invisible to the eye of the observer, it will become visible by merely filling the basin with water (*e*), for then the rays of light from the ewer which formerly took the direction of *c*, and did not reach the eye of the observer, will now pass in the direction of *d b*, and so the coin will be seen.

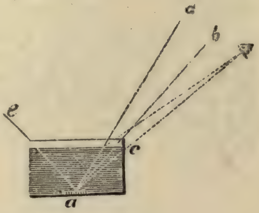

Fig. 77.

The form of the surface of the body on which the light falls modifies greatly the further direction of the ray. Thus, let us suppose that three rays start from the same point, *a* (Fig. 78), traverse the air, and fall on the surface of a convex lens. The ray *a c* striking the surface of the lens perpendicularly will pass directly through it, experiencing no deviation;

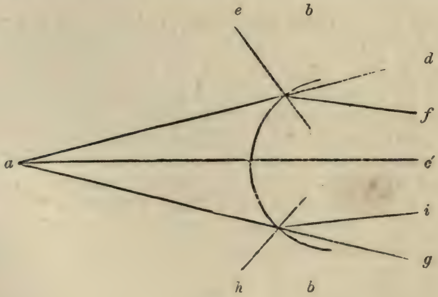

Fig. 78.

but the ray *a d* will be refracted at *e*, and proceed towards the perpendicular *e f*; the same will happen to the ray *a g*, which being refracted at *f*, will become *a i*. By this refraction, rays of light passing through the lens meet at last in a focus.

When the surface on which the rays strike is concave instead of convex, the opposite effect takes place, as may be understood by figure 79, in which *b b* represents the concave surface, *a* the point whence the three rays start, *a c* the perpendicular ray passing directly through, and the rays *a d* and *a i* will assume the direction of *a f* and *a g*.

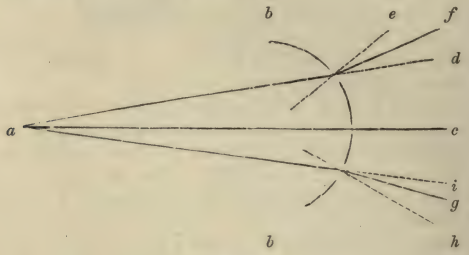

Fig. 79.

The deviation which the rays of light thus experience is proportionate to the convexity of the lens; and the degree of refraction is also in the ratio of the density of the body and its combustibility.

§ 233. Apply these principles to vision. When the rays of light fall on the cornea, some are reflected, and this gives to the eyes their brilliancy and the power of seeing objects reflected by them, as in a looking-glass. The rays passing through the dense cornea are refracted towards the perpendicular; they now meet the aqueous humour, which being less refrangible than the cornea, restores them somewhat to their primitive direction. Thus a greater number of rays pass through the pupil than could have happened by any other arrangement. The rays which strike the iris are absorbed or reflected; those falling on the pupil pass directly through it, which of course admits more or less light, according as it is more or less contracted. Under a strong light the pupil diminishes; with a feeble light it dilates. The rays now meet the surface of the lens enclosed in its capsule, and are thus brought to a focus, which falls on the retina, the rays having in the mean time passed through the vitrine or vitreous humour of the eye.

§ 234. It has been proved by many simple experiments that the image is represented on the retina, and that it is reversed; the following figure (Fig. 80) explains how this happens. The rays of light proceeding from the point *a* fall on the retina at *b*; those from *c* impinge the retina at *d*; thus the object is precisely reversed as painted on the retina.

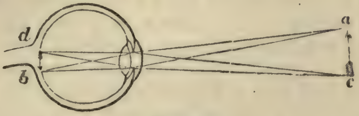

Fig. 80.

§ 235. The pigment covering the posterior surface of the iris, and all the inner surface of the choroid, is necessary for perfect vision, as may be seen by examining the eyes of albinos: it is only at night that their vision becomes distinct.

§ 236. The globe of the eye is the most perfect of all optical instruments; for whilst it is in general achromatic, it presents no aberration of sphericity,* and its range is considerable. It possesses the power of adaptation to various distances in its normal condition, although it has not been satisfactorily explained on what structure this depends. Within a short range it is obviously connected with the presence of two eyes.

In some the eyes have not this power. *Presbyopia* depends apparently on a deficiency of convergence of the rays of light whilst passing through the humours of the eye; hence persons so affected do not see distinctly objects near at hand.

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* By achromatism is meant the power of causing the light to deviate from its course without developing or decomposing its rays into their primitive colours.

The aberration of the sphericity consists in the reunion of the rays of light which fall on different parts of a lens with foci distinctly different, whence results a want of clearness in the images. To prevent this aberration of sphericity, as it is called, opticians place before the lens a sort of diaphragm, pierced with an opening. The iris in the eyes of animals is supposed to perform this function of correction.

An opposite defect is *myopia,* by which distant objects are rendered indistinct, or not visible. The habitual use of a strong lens has been thought equal to the production of this disease. The myops has the sight improved with age, and he may in time fall into the opposite condition, namely, become presbyopic. By glasses, man endeavours to remedy both defects.

§ 237. Insensibility to the rays of light is called *gutta serena.* All parts of the retina are equally susceptible of impressions, but it is the centre or in the axis of vision that this sensibility is most acute.* The various points of the retina may be exhausted of their sensibility by too strong a light or by gazing intensely for a long time at one object. The impression also which every object makes on the retina, continues for a certain time after the object has been removed; thus it is that a body moving in a circle with great rapidity resembles a ring or hoop, and that a wheel turning with great rapidity resembles a disc.

§ 238. The section of the optic nerve produces immediate blindness. But injuries of the thalami nervorum opticorum, or of the corpora quadrigemina, also effect the same; and thus it is evident that these bodies have the most intimate relation with the optic nerves and the function of vision.

When the cerebral hemisphere of one side has been destroyed in a living animal, it is the opposite eye which loses its power; and this is partly explained by the anatomical fact of the decussation of the optic nerves; by this decussation, the right retina derives most of its fibres from the left side of the brain, and *vice versâ.*

§ 239. *Motor Organs of the Eyeball.*—The apparatus of vision is composed of the eyeball and its appendages; of these, let us first examine the muscles.

§ 240. The muscles enabling us to direct the eyeballs, and consequently the axis of vision, upon any point, are six in number. They are attached posteriorly (with one exception) to the osseous orbit, around or near to the entrance of the optic nerve, and by their other extremities to the sclerotic or fibrous tunic of the eyeball (Fig. 81). The globe of the eye rests on a cushion of a fatty cellular substance, and thus these muscles can readily move it in all directions. The nerves, besides the optic, are the third, fourth, a branch of the fifth, and the sixth pairs.

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* It is a remarkable fact that at the point where vision is most distinct, the pulpy retina is wanting in man and in the apes of the Old World. The appearance is called the foramen centrale retinæ.—R. K.

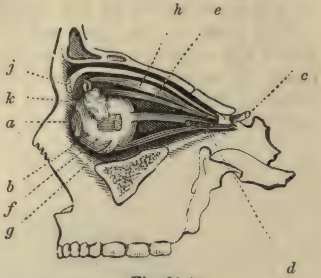

Fig. 81.[*]

§ 241. *Protecting parts of the Eye.*—These are, 1, the osseous orbits, requiring no special description here.

§ 242. 2. The eyebrows, the eyelids, and the tears. The eyebrows require no description: their form is sometimes characteristic of different races of men.

§ 243. The eyelids are two in number, and are horizontal. A third, when present, is vertical; they are called upper and lower, and differ in their anatomical structure. Externally they are formed of a delicate integument, supported each by a fibro-cartilage (cartilago tarsi); internally they are lined by the membrane called conjunctiva, which, besides forming a layer of the eyelids, invests the front of the eyeball. On the edges of the eyelids are observed cilia or eyelashes, and a little behind these the Meibomian glands are seen; these secrete a peculiar matter, preventing the adhesion of the eyelids during sleep. Further, in each eyelid the orbicularis muscle, or sphincter, gives a layer, and in the upper eyelid we find the termination of the muscle called levator palpebræ superioris, which raises the eyelid from off the surface of the eye.

The uses of the eyelids are obvious. The sub-mucous character of the conjunctiva assists in enabling the eyelids and eyeball to play freely on each other; but this is not sufficient, and accordingly, to secure to the surface of the eye the requisite degree of moisture, the tears have been provided.

§ 244. The lachrymal apparatus is composed of a glandular body, placed within the orbit, but exterior to the eyeball. From this so called lachrymal gland, a few ducts proceed and penetrate through the conjunctiva towards the outer

[*] Vertical section of the orbit.—*a*, the cornea; *b*, the sclerotic; *c*, the optic nerve; *d*, inferior rectus muscle of the eye; *e*, rectus superior; *f*, rectus externus: a portion has been removed to show the optic nerve; *g*, extremity of the small oblique muscle; *h*, the great oblique or trochleator; *i*, levator of the upper eyelid; *k*, lachrymal gland.

angle of the eye; by these the tears are conveyed to the surface of the eyeball. Here they are spread over the surface by the movements of the eyeball and eyelids, until they collect towards the inner angle of the eye, where will be found the openings of two small ducts (puncta lachrymalia) ready to convey away the superfluous tears. The fluid entering these two short ducts is conveyed by them into the lachrymal sac, which again communicates with the inferior meatus of either nostril by the nasal duct. When this is obstructed, the tears flow over the lower eyelid, constituting the disease called fistula lachrymalis.

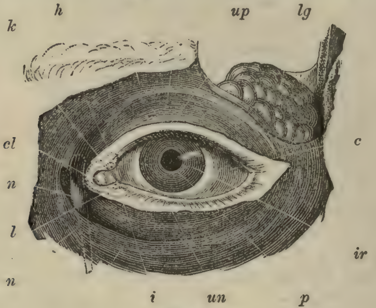

Fig. 82.*

Towards the inner angle of the eye is a small body, called the caruncula lachrymalis; also a fold of the conjunctiva, which is very small in man, being merely the vestige of a structure which, in some other animals, as in birds, is carried to its highest development.

[This fold is in fact the rudiment of the third or vertical eyelid in birds.—R. K.]

§ 245. The structure of this apparatus is pretty nearly the same in all mammals, birds, reptiles, and fishes. The eye in certain mollusca also resembles the eye of animals much higher in the range; but in most of this class the structure is very different, and as we descend to insects, crustacea, arachnides, &c., the difference in structure becomes more and more striking. These peculiarities will be adverted to hereafter.

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* *h*, *i*, punctum lachrymale. The two canals, *k* and *l*, open into the lachrymal sac *n*, which passes off into the lachrymal duct; *lg*, lachrymal gland; *p*, pupil; *ir*, iris; *c*, cornea; *cl*, caruncula lachrymalis; *up*, upper, and *un*, under eyelid.

OF THE MOVEMENTS.

Muscular Contraction.

§ 246. By sensation, man and animals perceive the external world; by motion, they react upon it. This latter series of functions is dependent on the property of *contractility.*

In some very simply organized animals, every part of the body seems susceptible of contracting and elongating itself, as in the hydra (Fig. 4); but as we ascend in the scale of animals we find that the property belongs exclusively to the *muscular fibre.* Collected in masses these form the *muscles,* which again constitute the *flesh* of animals. Their colour, which varies from a deep red to whitish, depends on the presence of the blood, and is not inherent in their structure.

§ 247. *Structure of the Muscles.*—The muscles are composed of fasciculi, or bundles of fibres united by cellular tissue, and these again of bundles of fibres more and more delicate, until an elementary fibre, or what may be considered so, is reached, and this can only be seen by means of the most powerful microscope. It seems as if it were composed of a series of discs. After death the muscular fibre is soft, and easily torn; during life it is firm and elastic. It is composed essentially of *fibrin,* to which are united albumen, osmazome, and some salts.

§ 248. By means of certain stimulants, such as *the will,* muscles contract; that is, they swell, shorten themselves, and become extremely hard; the phenomena may readily be observed by bending the fore-arm upon the arm.

The mechanism by which this is effected has not yet been discovered. One thing alone is certain, that the two extremities of the fibre or muscle approach each other, and thus, of necessity, act on whatever they may be attached to that is moveable, displacing one or both, and of course the body itself. Hence these organs have been called the *active* organs of motion, in contradistinction to the bones, which are *passive.*

§ 249. The muscles are attached to the bones by fibres of great strength, insensible, and of a dead-white colour; they are called tendinous or tendons; when membraniform in their arrangement they are called aponeuroses.

[The true aponeuroses envelope the muscles of the limbs, and form, as it were, a system apart from the tendons.—R. K.]

§ 250. *Influence of the Nervous System on Muscular Contraction.*—The muscles are the only parts of animals which possess the faculty of contracting; but this property is displayed only through the influence of the nervous system.

§ 251. *Influence of the Nerves.*—Each muscular fasciculus receives several nervous filaments. These proceed parallel with the fibres enclosed in a neurilemma: they also pass transversely across the muscular fibres and form loops, but how they terminate is not known. They seem to form a continuous circle.

By cutting the nerve across which supplies a muscle in a living animal, the muscle becomes paralysed. By compressing the brain of a living animal, all power of motion is lost.

§ 252. The nature of this influence of the nerves over the muscles has been much investigated; and the inquiry led Galvani and Volta to some brilliant discoveries. They proved that electric currents, however produced, act on muscles in a similar way to *the will*, producing contractions in them even after death; and so closely did the phenomena resemble each other, that it was at first thought that electricity, produced in the brain, and flowing thence into the muscles, was the efficient cause of muscular contraction—a hypothesis incompatible with certain facts recently observed. The nervous system is, no doubt, the determining cause of muscular contraction.

§ 253. Muscles present very important differences amongst themselves: some obey the will; others, in addition to this, also act independently of it; whilst there are others over whose acts the will has no power. The muscles of the limbs may be cited as instances of the first class; those of respiration belong to the second; the heart and stomach to the third.

The muscles of voluntary motion, as they are called, differ generally from the involuntary, in being marked with transverse striæ; but the fibres of the heart have these striæ, although it is in no respect a voluntary muscle.

§ 254. The muscles obeying the will all derive their nerves from the cerebro-spinal axis.

§ 255. *Influence of the Encephalon.*—A transverse section of the spinal marrow in a living animal paralyses the action of all the muscles supplied by nerves which leave the spinal marrow below the section; those above the section remain uninfluenced. The destruction of the brain paralyses all the muscles. Injury done to the *corpus striatum* renders the muscular movements confused and uncertain; the power of retiring is lost, the movements being always in advance: an injury done to the cerebellum (in birds) seems, on the contrary, to disable the animal from advancing; its movements are constantly backwards.

By dividing vertically in a living animal one hemisphere of the cerebellum, or one side of the pons, the animal moves incessantly round and round towards the injured side. The vital point of the encephalon seems to be close to the origin of the pneumogastric nerves. The cerebellum and the adjoining parts of the brain seem to regulate the movements of locomotion.

The movements which, though obeying the will, yet take place independently of its influence, seem to be derived, then, from the influence of the spinal marrow. The respiratory movements, for example, go on after the brain has lost its influence over the respiratory muscles.

§ 256. *Influence of the Ganglionic System.*—The muscular fibres, which are completely independent of the will, receive their nervous influence from this system.

§ 257. Thus it would seem that, whilst volition proceeds from the brain, the regulation of the movements proceeds from the cerebellum; whilst, in respect of those muscular actions which are independent of the brain, the principle of action seems to reside in the spinal marrow and ganglionary system.

§ 258. *Duration and Force of the Muscular Contractions.*—The contraction of the muscular fibres is a phenomenon essentially intermittent; they relax and contract alternately. Even the heart does this; but the voluntary muscles require a much longer interval of repose; a lassitude comes on at last, rendering all further action impossible.

Muscular fatigue varies much in different individuals; so also does the strength of contraction displayed. In passion and in a maniacal state it is prodigious. The development of the muscular system is best seen in the athlete.

Of the Apparatus of Motion in General.

§ 259. The function we have now to consider is chiefly mechanical; it respects the various movements of animal bodies.

In the lowest animals the muscles are all connected with, and dependencies of, the integument, which is soft and flexible, and by acting on this, they move the body in whole or in part; but in animals of a more perfect structure, the motor apparatus becomes more and more complex, and is formed not only of muscles, but of a skeleton, itself composed of solid parts calculated to augment the precision, the extent, and the force of the movements, to protect the viscera against external violence, and to determine the general form of the body.

§ 260. This framework or skeleton, to which the muscles are chiefly attached, is in man, and all animals called vertebrate, situated internally, and is covered by the soft parts.

In some fishes (as in the skate) the skeleton is formed of a white, opaline, compact, homogeneous substance, at once very resisting and elastic. It is called cartilage. In all animals, when very young, the skeleton is at first cartilaginous; but this condition, which is permanent in certain fishes, is only transitory in the greater number of animals, and the cartilaginous pieces soon become charged with calcareous salts, by which they become firm, hard, comparatively brittle: in this state they are called *bones.*

§ 261. *Of the Bones.*—To prove the presence of cartilage as the basis of all bones, all that is required is to immerse a bone in dilute muriatic acid, which, dissolving the calcareous part, leaves a cartilage of the precise form and dimensions of the bone itself. According to Berzelius, the bones of the human skeleton are composed of cartilage, 32·17; vessels, 11·3; phosphate of lime, with a little of the fluorate of calcium, 53·04; carbonate of lime, 11·30; phosphate of magnesia, 1·16; soda, with a little of the chlorine of sodium, 1·20—in 100·00 parts. The same chemist found the bones of the ox to be similarly composed, but with much less carbonate of lime. Thus bones by boiling afford much gelatine.

The ossification of the skeleton commences with various osseous points in the cartilages; these are called nuclei or germs. In youth they are numerous, but they gradually coalesce; thus the femur, in a young person composed of five distinct portions, is at last formed of one. In the lower vertebrate animals many of those remain distinct which in the higher coalesce or become fused.

The surface of bone is covered with a cellulo-fibrous and vascular membrane, called periosteum. The bones themselves are composed of a compact tissue externally, and a cellular and reticulated or cancellous internally.

In the interior of the long bones are found cavities containing marrow. The tissue itself, when examined under the microscope, seems composed of tubes or cellules, surrounded with concentric lamellæ, between which may be seen opaque ovoid corpuscles.

§ 262. The bones vary much in form, and anatomists have divided them into long, short, and broad. Their surfaces present elevations (processes) and depressions, some of which are for the attachment of muscles.

§ 263. *Articulation of the Bones.*—By articulation is meant the union of two or more bones; they are divided into the immovable or fixed, and the moveable. The fixed may be effected by juxtaposition, suture, and implantation; of the first, certain bones of the face offer an example; the bones of the cranium unite chiefly by suture, and the teeth are fixed into the alveoli by implantation; this mode of articulation is also called gomphosis.

§ 264. In the moveable articulations, the bones are held in their place by ligaments maintaining them in juxtaposition.

This bond of union is sometimes a fibro-cartilage, which permits the bones to move simply by reason of its elasticity; in other joints, the bones slide over each other, and are held in their place by ligaments attached to both bones, and permitting of motion only in certain directions; this mode of articulation is called *articulation by contiguity*, and it always exists where extensive motions take place. To meet the friction caused by this, the extremities of the bones are further provided with a cartilage of incrustation, and a synovial membrane representing a serous membrane in miniature, and is constantly bedewed with an unctuous fluid, called synovia, serving the purpose of a joint-oil. By means of this membrane the air is effectually excluded from the joints, so that the relative position of the bones to each other is further secured by the pressure of the external air on the exterior of the limb.

§ 265. *Action of the Muscles on the Bones.*—All the muscles destined to perform extensive movements are attached to the bones by their two extremities, so that by contracting they displace the more moveable bone in the direction of that which is less moveable or fixed. Thus, generally speaking, the muscles intended to move the fingers proceed from the fore-arms; those moving the fore-arms are attached to the arms or shoulders; and those acting on the arms have their fixed points in the trunk. But they may of course move the parts to which they are attached by either extremity, or both. To a certain extent also, the direction of the movement determines the position of the muscles. Thus, the flexors of the fingers are situated on the front of the arm; the extensors on the back of the limb. When different muscles act in producing the same movement they are called *congenerous; antagonistic* if they produce opposite movements. Finally, they are named, from their uses, flexors, extensors, abductors, &c.

§ 266. The strength of a muscle depends no doubt, *cæteris paribus,* on its size; but the effect depends also, in a great measure, on its mode of attachment to the bone.

Thus, all things being equal, the movement of a muscle will be so much the more extensive the less obliquely it is attached to a bone.

In fact, if the muscle, *m* (Fig. 83), whose force we shall consider as equal to 10, be fixed perpendicularly to the bone *l*, whose extremity *a* is moveable on the point of support *r*, it will have to overcome only the weight of the bone, and will carry it from the position *a b* in the direction of the line *a c*, thus making it traverse, to the point to which it is inserted, a space which we shall represent by 10. But if the muscle acts obliquely on the bone, in the direction of the line *n b*, it will then have a tendency to carry it in the direction of *b n*, and consequently to cause it to approach the articular surface *r*, on which it rests as a point of support. But this being an inflexible body, this displacement cannot take place; the bone can only turn on the point *r* as on a pivot, and the contraction of the muscle *n*, without losing any of the energy assigned to it, can only carry the bone in the direction of *a d*. Three-fourths of its strength will be lost, and it will only be equal to effect a displacement for which one-fourth of the strength expended would have sufficed had its attachment been perpendicular to the bone as the muscle *m*.

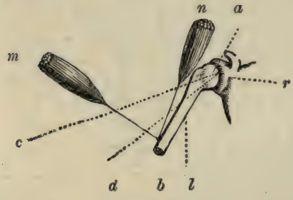

Fig. 83.

Now in animal bodies, muscles are generally inserted very obliquely, and thus very unfavourably in respect of their intensity of contraction. The enlargement of the extremities of the bones, as compared with the shafts, serves to counterbalance this obliquity in a certain degree, giving to the joints at the same time more security. The tendons (*i*) of the muscles (*m*) situated above the articulations, are inserted generally immediately beneath the enlarged extremity of the bone, and thus reach the moveable bone (*o*) in a direction more approaching the perpendicular, as may readily be understood by comparing Figure 85 with 84.

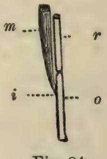

Fig. 84.

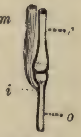

Fig. 85.

§ 267. The distance which separates the point of attachment of the muscle from the point of support on which the bone moves, and of the opposite extremity of the lever which this organ represents, influences also in the most powerful manner the effects produced by its contraction.

The bones represent *levers*, which move on a fixed point, called the *point of support*. The force which puts the lever in action is the *power*, and that which opposes its displacement is the *resistance*. Finally, the name of *arm of the lever* of the power, and *arm of the lever* of the resistance, is given to the distance separating the point of support from that to which is applied one or other of these forces.

Now the length of these arms of the lever has a powerful influence over the force required to produce an equilibrium to a given resistance. Observe the mechanism of the balance called *steelyard* (Fig. 86). The beam is divided into two unequal parts by the point of support *a*. At the extremity of one of the branches (*r*) which is very short, is placed the resistance, that is, the object to be weighed; and on the other (*p*) slides any weight which produces the equilibrium to a weight or resistance, always the more considerable that it is further removed from the point of support, and that we

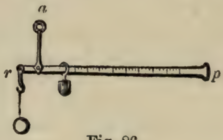

Fig. 86.

elongate, in consequence, the arm of the lever of the power, the lever of resistance remaining always the same.

On the same principle it is that we can raise a so much greater weight with the arm flexed instead of extended. It is a question (see the figure) of shortening or lengthening the respective arms of the lever to or from the point of support. By mechanics we learn that, in order to establish a perfect equilibrium (or to weigh the body as in the figure) in any lever, it is necessary that the resistance and the power (the weight and the weighed body) be reciprocally proportional to the length of the arms of the lever; that is to say, that multiplied by these arms of the lever respectively, they both give the same product.

Thus, to produce an equilibrium to a resistance (*r*) equal to 10, applied to the extremity of a lever (*a b*) of a length equal to 20, it is necessary that the power (*p*), if it be applied to the same point (*b*) and consequently equally distant from the point of support *a*, be also equal to 10; but if it were applied to the point *c*, to produce the same effect it must be equal to 20; for the resistance equal to 10 being multiplied by the length of its arm of the lever 20, will give as a product 200; and on the other hand, the arm of the lever of the power (*c d*) being only equal to 10, this must be multiplied by a force equal to 20 to give the same product, 200. Finally, by placing the former still nearer to the point of support at *d*, a force must be given, but equal to 100, for its arm of the lever will no longer be more than 2, and 2 × 100 = 200.

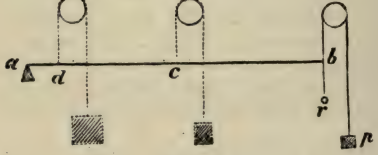

Fig. 87.

The disposition of the levers has as much influence over the rapidity of the movements produced as over their force; and if by employing a power comparatively feeble we may thus overcome a much stronger resistance, we may also, by employing moving force having a certain quickness, obtain, by means of these instruments, a movement slower or more rapid.

Thus let us suppose that the power (*p*) acts on the lever (*a r*) so as to cause it to pass to the point of insertion *c*, a space of 5 in a second, it will displace at the same time the extremity (*r*) of the lever, and will cause it to arrive at *b* with a quickness equal to 25, for the distance passed through in equal times by this point will be five times greater than that passed through by the point *d*. With a force equal in rapidity to 5 we produce, by applying it to the point *c*, the same result as if we applied to the point *r* a force having a quickness equal to 25. But all that is gained in rapidity is lost in power or force; for it is chiefly by extending the arm of the lever of resistance to a length disproportionate to that of the force that we obtain these results.

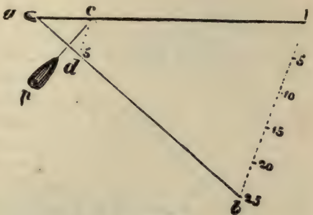

Fig. 88.

Now, in the animal economy almost all the levers are so disposed as to favour rapidity of motion at the expense of force. Thus, in lowering the extended arm, if the rapidity with which the muscles contract be such that their point of insertion be displaced three inches in a second, the extremity of the limb will pass from its original position with a rapidity of nearly three feet per second.

Description of the Motory Apparatus in Man.

§ 268. The motory apparatus — as we have already mentioned—is composed in man and all the vertebrata of the skeleton, the muscles, and the articular apparatus.

The skeleton is divided into the head, trunk, and extremities.

§ 269. *The Head.*—The skeleton of the head is composed of two portions—the cranium and face. The cranium lodging the brain, cerebellum, and pons, with their membranes, the vessels proceeding to and from them, and the roots of the cranial nerves, is composed of eight bones; the frontal or coronal (Fig. 89 *f*): the two parietal, *p*; the two temporal, *t*; the occipital, *o*, behind; and the sphenoid, *s*; and the ethmoid below. These bones are generally broad and flat, of a compact tissue externally and internally, and are immovably united by sutures dovetailed into each other. This adds greatly to the strength of the cranium and of the arch it forms: the interlocking of the sphenoid also with all the other bones of the cranium contributes greatly to its general strength.

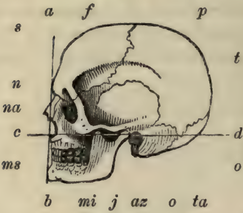

Fig. 89.*

At the base of the skull will be seen a great number of apertures for the egress of the cranial nerves, and of the bloodvessels entering or leaving the cranium. In the occipital bone, close to its condyles, is the *foramen magnum*, by which the medulla spinalis, or "myelon," passes towards the brain; the vertebral arteries, also intended to supply the brain, enter by this large aperture. The cranium is articulated by means of these two *condyles* of the occipital bone with the atlas or first cervical vertebra, on which it rests nearly, but not quite, in equipoise, so that during sleep the head naturally falls towards the chest. The powerful muscles moving the head are chiefly placed on the back of the neck.

At the sides of the cranium may be seen the *mastoid* processes (Fig. 91 *a*), to which are attached the sterno-cleido-mastoid muscles, seen so conspicuously on the front and sides of the neck; by means of these the head is turned from side to side. Anterior to these may be seen the orifice leading to the middle ear, and to which the external ear is attached (§ 222, Fig. 73, *e*).

§ 270. The following bones compose the skeleton of the face: the superior maxillary, 2; palatine, 2; malar, 2; lower turbinated, 2; lachrymal, 2; vomer, 1; inferior maxillary, 1. To these some add the *intermaxillary*, of which the vestiges remain in man, 2; the sphenoidal turbinated, 2; finally, the ethmoid and sphenoid contribute also to the formation of the face.

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* *f*, frontal or coronal; *p*, parietal; *t*, temporal; *o*, occipital; *s*, the sphenoid; *n*, the nasal; *ms*, superior maxillary; *j*, jugal or cheekbone; *mi*, inferior maxillary or lower jawbone; *na*, anterior opening of the nostrils; *ta*, auditory canal or foramen; *az*, zygomatic arch; *ab*, *cd*, lines forming the facial angle.

These bones assist in forming certain osseous cavities connected with the face, as the orbits (§ 241), the nasal fossæ, and the mouth.

The skeleton of the nose is completed by cartilages, which being removed in the skeleton, makes the anterior openings of the nasal fossæ appear so large. These cavities are very large and complex, communicating with the anterior and posterior ethmoid cells; the sphenoidal and superior maxillary and frontal sinuses, and also with the middle ear. They are separated from each other by an osseous and cartilaginous partition or septum, and from the mouth by the osseous palate. It is in the cavities of the nostrils that we find the so-called turbinated bones, of which two are distinct bones, the other four being but processes of the ethmoidal. The importance of these bones, as regards the sense of smell, has been already adverted to.

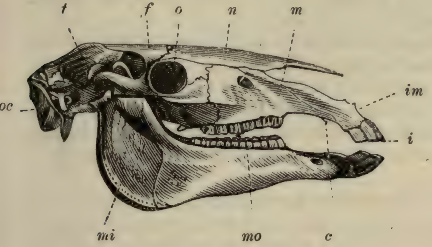

Fig. 90.—Head of the Horse.*

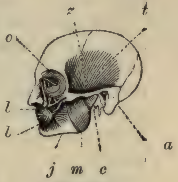

Fig. 91.†

It is into the superior maxillary bone (speaking with reference to man) that are implanted all the teeth of the upper jaw.‡ In youth it is, like most other bones, formed of several distinct germs, nuclei, or portions, which ultimately coalesce.

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* *oc, t, f,* occipital, temporal, and frontal bones; *n*, nasal bone; *m*, superior maxillary; *im*, intermaxillary; *mi*, inferior maxillary; *o*, orbit; *i*, incisive teeth; *c*, canine; *mo*, molar.

† Principal muscles of the face and head:—*o*, orbicular muscles of the eyelids, intended to close the eyelids and protect the eyes; *bb*, orbicular muscle of the lips, intended to close them and to contribute greatly to speech, the expression of the passions, &c.; *j*, muscles of the cheeks; *m*, masseter muscle, intended to close the jaws by raising the lower maxillary bone; *t*, temporal muscle having the same function: *z*, zygomatic arch; *c*, articulation of the lower jaw; *a*, auditory meatus and mastoid process.

‡ Anatomists now generally admit that man has intermaxillary bones as

These intermaxillary bones which fuse so early in man, remain distinct throughout life in many mammals and others, and form a distinctive feature of the face. They are also called premaxillary (*i m* Fig. 90).

In man the germs of the lower jawbone become fused at an early age; in many mammals it is formed of two pieces, united by cartilage at the symphysis of the chin. A brief inspection of the lower jawbone shows its more remarkable points: its articular surface, by which it rests on the glenoid cavity of the temporal; the coronoid process projecting upwards in front of the condyle, and to which is attached the powerful temporal muscle; the alveolar edge of the jaw, forming its dentar portion; the symphysis or union of the chin, and the base and angle. The masticating muscles are very powerful, especially in the carnivora; and in some animals the disposition of the muscles rendering the arm of the lever of resistance equal to, or even shorter than that of the power, adds to their strength.

The hyoid or lingual bones (Fig. 31), placed in front of the neck, representatives of another apparatus, of which in man, mammals, birds, and most reptiles, we have only the rudiments, and which only attain their full development in fishes, give attachment to the muscles of the tongue and to others. They are not considered as part of the skeleton, properly so called.

§ 271. *The Trunk, or Torso.*—The most important part of the skeleton of the trunk is the vertebral column, composed of the bones called vertebræ. It supports the head, which may be considered as a continuation of it; but anatomists still speak of the vertebral column as a part distinct from the head. In this view it is composed of 33 vertebræ, namely,

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well as other mammals, which early become fused with the maxillary, so that nearly all traces of their early existence are lost. The *incisive* teeth always appear in these bones in the upper jaw, and whatever be their shape, so long as they belong to these bones are called incisive. Thus the enormous tusks of the elephant are called *incisors*, notwithstanding their shape and size, simply for this reason, that they grow in the intermaxillary bones. For the same reason we call the gnawing or cutting teeth of the beaver, porcupine, hare, rabbit, incisive teeth, and not merely from their functions. Notwithstanding, it is right to observe that the upper incisors of the rabbit grow from a pulp, the extremity of which is lodged in a small osseous cavity of the *upper maxillary bones*. They merely pass through the intermaxillary bones, which furnish them no doubt with their chief support, mechanically.—R. K.

7 cervical (*c*); 12 dorsal (*d*); 5 lumbar (*l*); 5 sacral (*s*); and 4 coccygeal (*cx*). It presents several curves when viewed in profile, but is straight when seen from before backwards, or from behind forwards. At first all the vertebræ are distinct, but with years certain of them become fused into one or more: the 5 sacral vertebræ generally unite so as to form one mass; and the coccygeal bones are also disposed to fuse into one bone in the adult.

The essential character of a vertebra (***with certain exceptions, however***) is to be formed or composed of a body and processes, and to have a foramen, or short canal, behind the body, in which the spinal marrow and its membranes are lodged. But the coccygeal vertebræ in man are quite rudimentary, and cannot be included in this definition. At the sides of the column are openings for the passage of the nerves; they are called the foramina intervertebralia, and are generally formed by the union of two vertebræ.

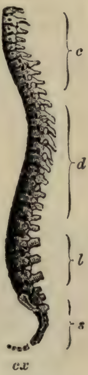

Fig. 92.

The body or centrum of a vertebra is a disc (*a*), with parallel surfaces, each united (with certain exceptions) to the adjoining vertebra by a substance called intervertebral; this is a fibro-cartilage of great strength, flexibility, and elasticity, on which the strength and mobility of the column greatly depends.

Four articular processes also greatly contribute to its strength, and limit its movements in certain directions. The spinous process (neural spine) *b*, as well as the transverse processes or parapophyses *c*, give attachments to numerous muscles, and the latter support the ribs.

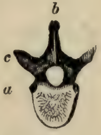

Fig. 93.

The mobility of the column varies in different regions, being most extensive in the neck and loins. The erector muscles of the spine, those intended merely to raise the body upright, and to counterbalance the weight of all the viscera situated in front, are placed on the dorsal side of the column, filling up the grooves called vertebral, and which may be seen extending on either side the spinous processes, from the head quite to the extremity of the sacral vertebræ. They seek attachments also in the ribs and transverse processes of the vertebræ.

The spinous processes (neural spines) are long and powerful

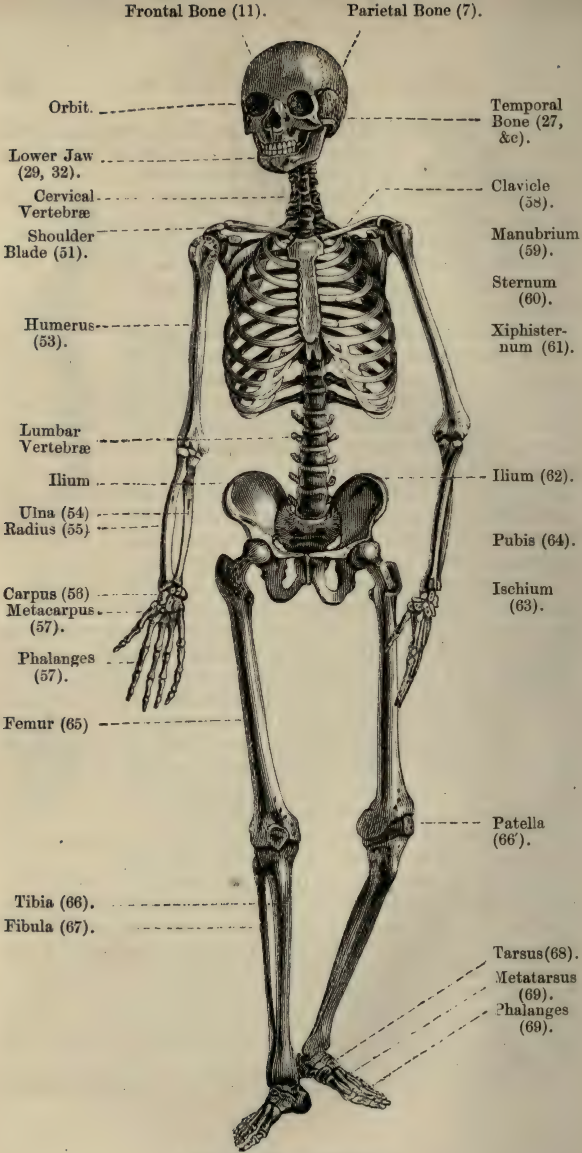
Frontal Bone (11).
Parietal Bone (7).
Orbit.
Temporal Bone (27, &c).
Lower Jaw (29, 32).
Cervical Vertebræ
Clavicle (58).
Shoulder Blade (51).
Manubrium (59).
Sternum (60).
Humerus (53).
Xiphisternum (61).
Lumbar Vertebræ
Ilium
Ilium (62).
Ulna (54)
Radius (55)
Pubis (64).
Carpus (56)
Metacarpus (57).
Ischium (63).
Phalanges (57).
Femur (65)
Patella (66′).
Tibia (66).
Fibula (67).
Tarsus (68).
Metatarsus (69).
Phalanges (69).

Fig. 94.—Human Skeleton.

in many quadrupeds (Fig. 95). The muscles, on the other hand, situated on the flexor side of the body, are generally small, as being but little required.

The first cervical vertebra is called the Atlas, and is much more moveable than the others; it resembles a ring, and turns on its own centrum, which is immoveably connected with the second vertebra or dentata (axis). The movement of the head forwards and backwards takes place at the articulation of the occipital bone and atlas; rotation of the head is performed by the atlas and head moving as one around the *processus dentatus* of the axis or second vertebra. There exist check ligaments to prevent this movement going too far.

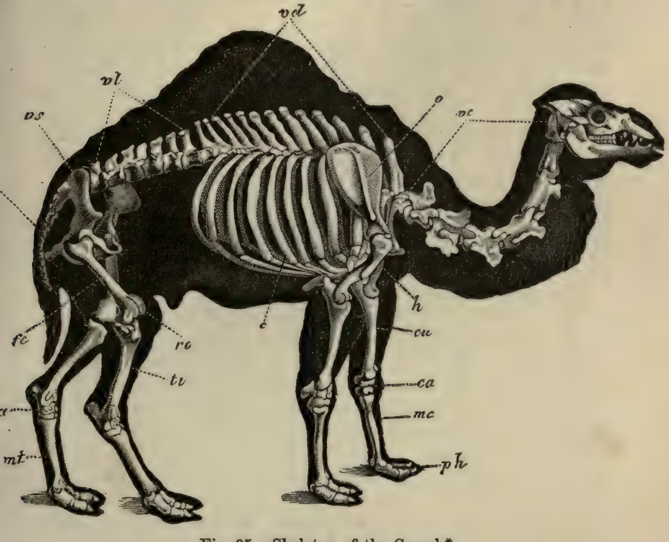

Fig. 95.—Skeleton of the Camel.*

§ 272. To the dorsal vertebræ are articulated the ribs,

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* The dark line represents the outline (*silhouette*) of the living animal; *vc*, cervical vertebræ; *vd*, dorsal vertebræ; *vl*, lumbar vertebræ; *vs*, sacrum or sacral vertebræ; *vq*, vertebræ of the tail, or caudal; *c*, the ribs; *o*, scapula; *h*, humerus; *cu*, ulna, or cubitus; *ca*, carpus; *mc*, metacarpus; *ph*, phalanges; *fe*, femur; *ro*, rotula; *ti*, tibia; *ta*, tarsus; *mt*, metatarsus.

24 in man,—*i.e.*, 12 on each side. The head of the rib rests on the vertebral column, and the tubercle on the transverse process generally; the anterior extremity of the rib is united to a cartilage, by means of which it is prolonged to the sternum, directly in the first seven ribs, and indirectly in the remaining five. Hence the division of the ribs into true and false, or *sternal* and *asternal* (Fig. 96).

§ 273. *Limbs.*—The skeleton of the limbs may be divided into a basilar portion, and a lever or extended and moveable part. In the pectoral extremity the basilar portion or shoulder consists of two bones, the scapula and the collar-bone or clavicle. With the scapula, a large and flat bone, is articulated the humerus or arm-bone. The articular cavity (glenoid) has but little depth. On the inner side of this glenoid cavity is a strong process, called coracoid, and on the dorsal side of the bone a strong spine, running from near its base, and terminating in a process called acromion; surmounting the shoulder-joints and attached to this process is the clavicle, a cylindrical and slender bone, comparatively; its other extremity is articulated with the manubrium of the sternum (Figs. 94 and 96).

The more obvious use of the clavicle is to maintain the shoulders apart, and hence the frequency of its fracture when forced towards the sternum. These clavicles are strong in birds of powerful flight, and weak in those differently circumstanced: contrast, for example, the eagle and the turkey. In animals like the horse, ox, &c., they are wholly wanting; the scapula, as the essential bone of the shoulder, never.

Numerous powerful muscles fix the shoulder-bones to the trunk; of these may be mentioned the trapezius, rhomboids, and levator of the angle of the scapula; a muscle of great power, even in man, but much more so in the larger quadruped mammals, as the horse, ox, &c., connects the scapula with the ribs, viz., the serratus magnus.

§ 274. The arm is divided into arm, fore-arm, and hand. In the skeleton of the arm there is one bone, the humerus; in that of the fore-arm two bones, the radius and ulna; the skeleton of the hand is subdivided into three segments, the carpus, metacarpus, and fingers; in the carpus there are eight bones; in the metacarpus five; and in each finger there are three bones, with the exception of the thumb, in which only two are reckoned.

The humerus has a ball-and-socket motion upon the scapula, and is moved by several powerful muscles, of which some proceed from the scapula (sub-scapular, supra-spinal, infra-spinal, teretes); others from the trunk, as the pectoralis major, latissimus dorsi. By its lower or distal extremity, it articulates with the radius and ulna.

§ 275. The radius and ulna form the skeleton of the fore-arm. Of these, the radius is the more moveable, and upon its rotation on the extremity of the humerus depends the movement of rotation and supination of the hand. There is no rotation at the elbow-joint, both bones moving on the humerus merely in flexion and extension; but it is close to this that the radius rotates on the ulna, and slides over the smaller head of the humerus, which movement determines the rotation of the hand in supination and pronation. The lower end of the ulna is styliform, and has interposed between

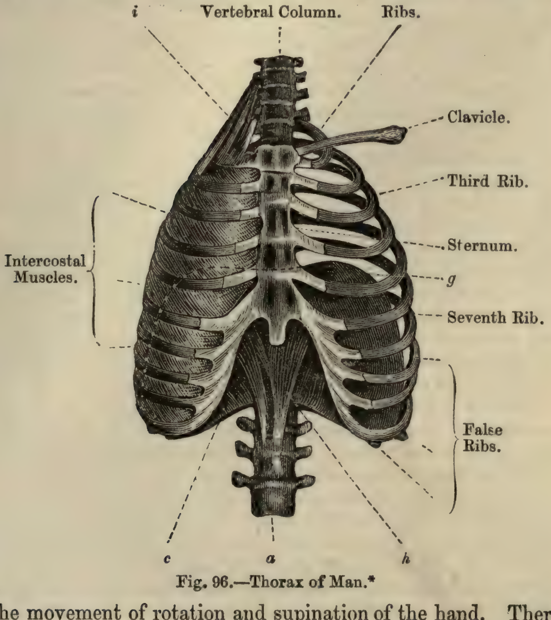

Fig. 96.—Thorax of Man.*

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* See explanation of this figure at page 77.

it and the carpal bones a fibro-cartilage of a triangular shape, which attaching the radius at its extremity to the ulna, permits the former to rotate around the lower end of the latter, which remains fixed.

These two bones at their carpal extremities also move readily in flexion and extension.

The process called *olecranon* belongs to the ulna or cubit; to it are attached the extensor muscles of the fore-arm.

§ 276. In the hand we have the carpus, metacarpus, and fingers, or digital portion.

The carpus is composed of eight bones, four in each row; they are scarcely moveable, and the strength of the arch they form is considerable. In the first row we find the *scaphoid, semilunar, pyramidal,* and *pisiform;* in the second row the *trapezium, trapezoides, magnum,* and *unciform.* On the flexor side of the hand they form with the anterior annular ligament of the carpus, a canal, in which are lodged and protected most of the flexor tendons, and one of the great nerves (median) proceeding to the palm of the hand.

The metacarpus is composed of a single row of small long bones, corresponding to the number of the fingers, all different and readily distinguishable from each other. Four of these move but little; the first, which supports the thumb, and which some view as the *proximal phalanx* of that finger, is very moveable, corresponding to the greater mobility of the thumb as compared with the other fingers.

Finally, the fingers have each three bones, called proximal, middle, and distal phalanges; in the thumb there are only two. The distal phalanx supports the nail, and is sometimes called the nail-bone, or ungual phalanx.

§ 277. When we consider the arm as a series of broken levers, we observe that the arm is longer than the fore-arm, and this longer than the hand: or, in other words, that the mobility of the structures and their flexibility and power of adaptation increase as we approach the extremity, properly so called.

§ 278. The structure of the inferior or pelvic extremities has the strongest analogy to that of the superior limbs, and the principal differences to be observed have a necessary relation to their functions; to make of them, in fact, instruments of locomotion rather than of prehension. Hence their solidity, at the expense of their mobility. They also have a basilar portion, the haunch, the representative of the shoulder, and an articulated lever, formed of three principal parts—the thigh, the leg, and the foot—corresponding to the arm, the fore-arm, and the hand.

§ 279. The haunch or basilar portion of the abdominal or pelvic extremity is composed of one bone on either side, the *os innominatum* or haunch-bone. In the young this bone is composed of three large portions, called pubic, iliac, and ischiatic portions. These have been considered analogous to the scapula, coracoid process, and clavicle. These bones, the ossa innominata, are articulated in the most solid manner with the sacrum by strong articulations, and with each other at the pubis; these joints are immovable in their normal state: with the sacrum and coccyx, the innominata form the osseous girdle, called the pelvis, surrounding the lower part of the trunk. To this basin or pelvis are consequently attached the powerful erectors of the spine, the muscles which are to move the lower extremities, and those which shut in the abdominal and pelvic cavities.

§ 280. In the thigh there is but one bone, the femur (Fig. 94). The head of this bone, by which it articulates with the pelvis, forms, with the cotyloid cavity of the haunch-bone, a perfect ball-and-socket joint, protected by a capsular ligament, permitting of circular movements, or nearly so. A short neck (*cervix*) connects the spherical head of the femur to a powerful cylindrical shaft, which enlarges towards its lower extremity, by which it articulates with the tibia. This is by much the longest and strongest bone of the body. Powerful muscles surround and move it in all directions, excepting backwards or in extension.

§ 281. The skeleton of the leg is composed of two bones, the tibia and fibula. The rotula or patella, attached to the tibia by a powerful ligament, or rather tendon, is a sesamoid bone, developed in a fibro-cartilage connected with the system of the tendons. The tibia carries the whole weight of the body, transmitted to it through the femur, which it transmits to the astragalus. There is no rotation at the knee-joint in general, nor at the ankle. The malleoli formed by the lower ends of the tibia and fibula assist in forming a case for the head of the astragalus.

§ 282. The foot, like the hand, is divided into three regions: the tarsus, metatarsus, and toes. In the tarsus there are seven bones, the astragalus, os calcis, scaphoid, cuboid, and three cuneiform bones; in the metatarsus there are five bones, reckoned numerically, from the inner to the outer side of the foot; and in the region of the toes, there are for the great toe, two phalanges, and for the others three; besides these, as in the hand, there are two sesamoid bones, constant and regular, developed in the tendon of the short flexor below the ball of the great toe.

In man the great toe cannot be opposed to the others; the second toe is the longest in all well-formed human feet. The tarsal and metatarsal bones form a strong arch towards the inner and lower surface of the feet, protecting the vessels, nerves, and tendons passing from the foot to the leg, and the opposite. The short flexors of the toes are placed in the sole of the foot; the tendo-Achilles, the strong tendon through which the extensor muscles act on the foot in walking, is attached to the tuberosity of the calcaneum. The size of the peroneal muscles is a peculiarity in the human leg. The same remark applies to the gastrocnemii muscles.

Of the Attitudes and of Locomotion.

§ 283. All mammals, birds, reptiles, and fishes have a skeleton formed on the same plan as in man. It gives to the body its general form, regulates its development and movements.

§ 284. *Station or Standing.*—With the exception of serpents, most animals rest on the soil by means of limbs or extremities. They stand by means of the action of the extensor muscles: and thus standing for a long time erect becomes more fatiguing than walking, for in this the flexors and extensors are used alternately.

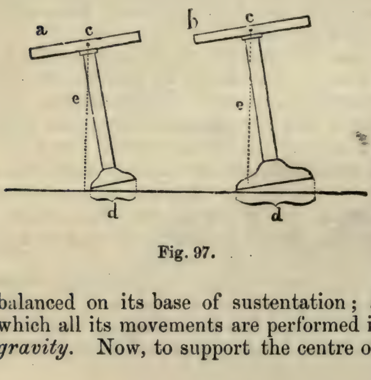

Fig. 97.

§ 285. But the body must also be *in equilibrio*, or balanced on its base of sustentation; and the point around which all its movements are performed is called the *centre of gravity*. Now, to support the centre of gravity, it is necessary that the *base of sustentation* be situated vertically below the centre of gravity. The wider, then, the base of sustentation is, the more secure the position: thus we stand safer on two feet than one; on the sole of the foot than on the toes or heel, &c.; for in proportion to the extent of the base of sustentation, so may the centre of gravity be displaced without risk of its falling beyond that base. The law holds good in all heavy bodies; thus, the table (*a*) represented in Fig. 97 must fall, because the vertical (*c*), let fall from its centre of gravity (*e*), would fall beyond the limits of its base of sustentation (*a*), or in other words, the foot of the table or the space occupied by it; whereas the table (*b*) would not fall, for the base of sustentation is sufficiently large to allow the vertical from the centre of gravity to fall within its limits.

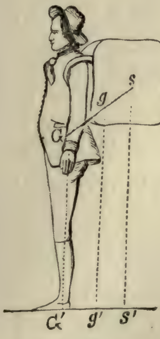

Fig. 98.

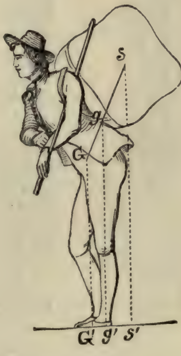

Fig. 99.*

On these simple principles may readily be explained the safety of the position of the quadruped as he stands on four limbs; how it becomes less safe on three, still less on two; and how readily the bird secures itself on one leg in consequence of the breadth of the foot which is the base of sustentation. Man stands readily on one limb, and with little fatigue, especially if he use the other to secure his equilibrium; for the centre of gravity being in him towards the middle of the pelvis, all that is required is to recline the body a little to one side, so that the centre of gravity may fall on the sole of the foot which receives the weight.*

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* To show the varying centre of gravity in man.

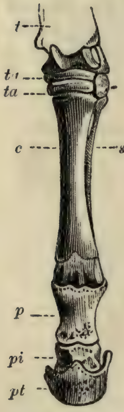

Fig. 100.†

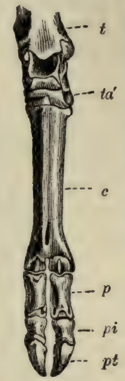

Fig. 101.

Most quadrupeds can neither stand on one foot nor even on the two hinder limbs; it is impossible for them to maintain, excepting for a few seconds, such a position; the base of sustentation is too narrow; their centre of gravity is towards the chest, and the muscles are not strong enough to maintain the attitude. But in man this position is easy, natural, and belongs to him by the character of his organization.

§ 286. In the vertical position it is chiefly the extensor muscles which are called into play; the limbs forming broken levers become fixed; the knee and ankle become immovable.

§ 287. Sitting is less fatiguing than standing; but the horizontal position is that alone which gives absolute rest to the body.

§ 288. *Walking.*—When we walk, one of our feet is carried forwards, whilst the other is extended on the limb; and as this forcibly extended foot rests or presses against a resisting soil, its elongation displaces the pelvis, and thus projects the whole body forwards; at the same instant, the pelvis turns a little on the femur of the opposite side, and the leg which at first remained behind, bends, is carried forward, and in its turn is placed on the soil, to carry forward the whole body by the extension of the foot. By the aid of these alternate movements of flexion and extension, each limb carries in its turn the weight of the body, and at each step the centre of gravity is pushed forwards. For an instant the body is carried alternately on one foot, and the centre of gravity is carried flexuously from side to side at each step, and this in proportion to the width of the pelvis.

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* Standing on one foot, using but little muscular effort, requires the centre of gravity to be thrown forwards so as to fall towards the fore part of the base of sustentation; the knee tends then to bend backward, but is fixed and rendered immovable by the posterior ligament of Winslow. Thus the knee becomes fixed by a mechanical artifice requiring but little muscular effort. But if we shift the centre of gravity so as to make it pass directly through the joint, a strong muscular effort is required to fix the knee-joint; the extensor muscles are called into play in order to fix the patella, and the position cannot in consequence be long maintained.—R. K.

† Fig. 100, hind foot of the horse. Fig. 101, foot of the stag; *t*, the tibia, *ta*, first row of the bones of the tarsus; *ta'*, second row; *c*, metatarsus or *canon* bone; *s*, styloid bone formed by the skeleton of a rudimentary finger;—there are two such; *p*, proximal phalanx, called the great *pastern; pi*, middle phalanx (little pastern); *pt*, distal phalanx, or coffin-bone of veterinarians.

§ 289. As the functions of every apparatus are always in relation with the structures, so the limbs of various animals show great variety in their disposition. Thus, amongst mammals, some are destined to move in water or on land—that is, to swim or walk, as suits them, or to swim only; others have the limbs formed for speed; others, as bats, fly like birds; some use their fore limbs only as instruments of prehension or touch; and yet the limbs in all these animals are formed precisely on one plan. In the swimming limbs of the seal, the wing of the bat, the fore limbs of the squirrel or mole, we find

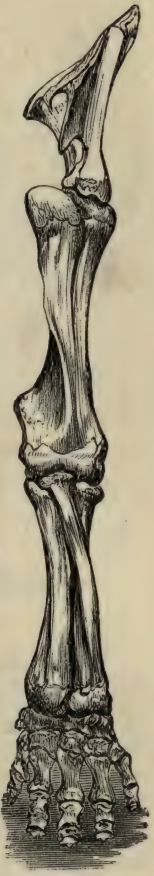

Fig. 102.*

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* Skeleton of the right fore leg of the Asiatic Elephant. In the construction of the legs of the elephant, Nature seems to have done her utmost to combine enormous strength with a remarkable degree of agility. The ulna, which in other animals falls off as it approaches the wrist, and is articulated only indirectly with the carpal bones, in the elephant, on the contrary, enlarges to a size even greater than the radius, and is articulated directly with the carpus. The other exception to the almost universal law of the falling off of the ulna, I discovered in the dugong, and pointed it out as one of the characters separating the dugong from the Cetacea, in which I had placed it. Long afterwards, the illustrious De Blainville accepted of my arrangement as the only correct one, and restored the dugong to the elephant, to which it more nearly belongs.

the same number and arrangement of the bones (Fig. 94) as in the human arm.

§ 290. In mammals organized for speed, the limbs are slender and the feet small; we see this in the horse, stag, and camel, in which the toes are but little divided (Fig. 95), and the number of the toes is reduced to its minimum; in the horse, for example, there is but one toe or finger perfect, two others being imperfect and concealed (Fig. 101); in others there are two, either alone or with vestiges of one or two others, and these always short and not very moveable.

In those also remarkable for speed of foot, the limbs are long; and this is a necessary result of the mechanical principles already explained.

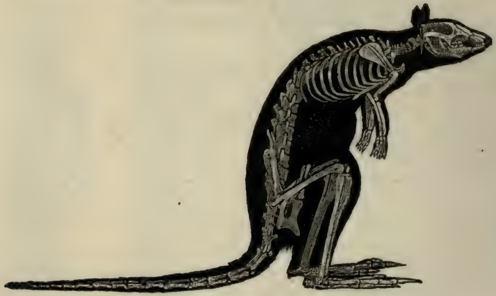

Fig. 103.—Skeleton of the Kangaroo.

§ 291. *Leaping.*—In walking, the weight of the body is sustained by a portion of the locomotory apparatus, whilst its centre of gravity is being pushed forward by the other part of the apparatus, so that man never ceases to touch the soil. In leaping it is otherwise; the body is thrown into the air, and becomes, as it were, a projectile. To effect this, the articulations are strongly flexed, so that, by a strong and forcible and sudden extension, the body may be forced upwards from the resisting soil. Between the body and the soil there is, in fact, an apparatus representing an elastic spring—the joints; on these extending violently and suddenly one of two things must happen, if the spring be sufficiently strong—either the soil must yield or the body, and this being generally the only moveable, gives way and becomes the projectile. Were the soil to yield under the feet, it is obvious that no leap could take place. With quadrupeds, it is principally the hinder extremities which act as the spring or force; and hence, in animals of great speed, as the antelope, horse, &c., these limbs are long, and flexed, and slender. In some, as in the jerboa and kangaroo, the anterior limbs are but little, if at all, used in progression.

§ 292. *Swimming or Flying.*—These movements are analogous to leaping, the only difference being in fact in the medium in which they take place. The points to be considered are, first, the medium, which in the case of flying is the air, and this, by reason of its rarity and the facility of its displacement, requires being struck with much greater force and rapidity than if it were water, or the still more resisting soil. Hence the great force required by birds in the muscular apparatus by which flight is effected. Second, diminution of the surface of the motory organs during the advance of the body, so as to offer less resistance to the passage of the body through the air. Now, these two conditions we shall find uniformly take place in animals which fly or swim naturally; the expanded foot of the seal diminishes during the moment of advance, and the wing of the bird approaches the sides; the flanges attached to the archimedean screw are but poor imitations of the tail-fin of the whale.

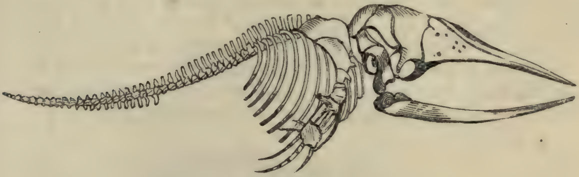

Fig. 104.*

§ 293. The palmated feet of the otter and seal, of the swan and duck, represent and explain the mechanism by which nature provides for the wants of an animal requiring at

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[*] Skeleton of the fœtus of the Greenland whale. The specimen was removed for me from the uterus of its mother, a full-sized Mysticetus or Greenland whale, by Mr. Robert Auld, one of my students. The skeleton was long in the museum in Old Surgeons' Hall, and is now in that of the University of Edinburgh.

times to swim at others to walk on the soil; the otter also furnishes a good example of this mechanism. But nature does not for all this depart from her great plan in the construction

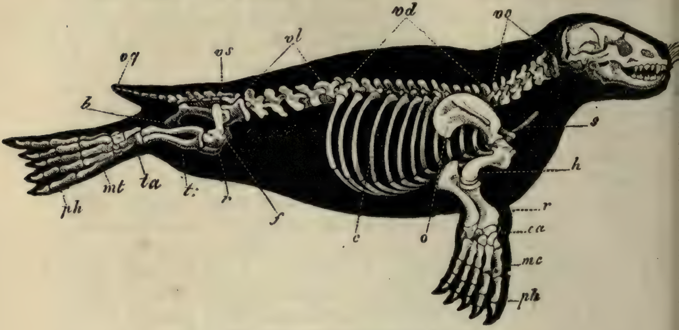

Fig. 105.—Skeleton of the Seal.*

of animals; the skeleton of the hand and foot of the seal resembles ours (Fig. 105), admitting that in some, as in the whale, the number of phalanges appears to exceed that of mammals generally, and that the fingers themselves seem to be replaced by a number of osseous pieces, reunited under a common integument, as is seen in the fins of fishes.

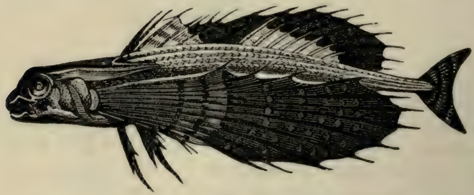

Fig. 106.—The Flying Fish (the Dactylopterus).

§ 294. The structure of the organs which enable an animal to fly, has much analogy with the fins generally; thus there are fishes (Fig. 106) which use indifferently for progression in air or water their pectoral fins.

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* The bones are lettered as in Fig. 95.

Some squirrels, and the *Galeopitheci*, have a wide expansion of the common integuments extending on either side, from the neck to the tail and hinder extremities; and by this they can support themselves in the air for a short time; it answers, in fact, the purpose of a parachute.

In the vertebrata, the wings are always formed by the pectoral extremities, without requiring on the part of the limb any very extraordinary metamorphosis. The figure (108) representing the skeleton of the bat explains this sufficiently; the phalanges of the fingers are much extended, and with them the integuments.

The wings of birds, which at first sight seem to differ essentially from the arm of man, the foot of the horse, and the swimming paw of the whale, in point of fact do not differ as regards the basis of the instrument, the skeleton. To the bones representing the fore-arm and hand, analogous to those of man, are attached the powerful feathers of the wing; the hand is small, and the digital portion merely rudimentary; but the basilar portion of the limb is always powerful, and perfectly adapted for flight.

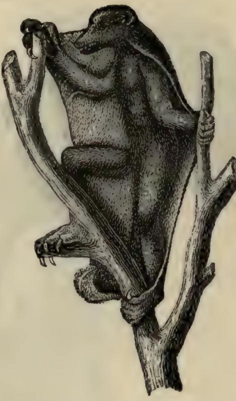
Fig. 107.—Galeopithecus. The Flying Lemur.

The wings of insects are constructed pretty nearly on the same plan as those of birds, but the tegumentary part is supported on horny stalks, instead of osseous, as in the vertebrata.

§ 295. *Organs of Prehension.*—By slight modifications in the form of the bones, and in the disposition of the articulations, the limbs become instruments of prehension, instead of mere locomotion and support. To be satisfied of this, it is only necessary to compare the pectoral and abdominal extremities in man, section by section, and bone by bone; the rotation of the radius, and the consequent movements of pronation and supination, together with an opposing thumb, constitute in reality the chief differences between the arms and limbs. Many apes of the New Continent (America) opossums, &c., have prehensile tails; amongst reptiles, the chameleon offers the same peculiarity.

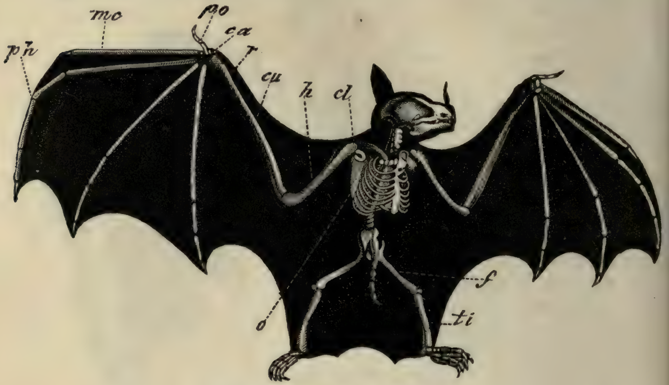

Fig. 108.—Skeleton of the Bat.*

OF THE VOICE.

§ 296. In certain of the lower animals there exists no trace of this faculty; in insects, the sound produced by the friction of their wings, or of some other tegumentary parts, is a necessary result of their movements,—as of flight, for example,—and can scarcely be viewed as a phenomenon of expression. But in the higher animals the voice acquires another importance: it is under the direction of the will; it is more varied, and depends on a totally different cause; for in all these, it is caused by the passage of the air through a determinate point of the respiratory canal, disposed in such a way as to cause the air to vibrate.

§ 297. The *larynx* (Fig. 31), surmounting the trachea and communicating directly with the pharynx, and by its means with the nostrils and mouth, is the organ of the voice in man and in mammals. It may be felt on the surface of the

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*** The bones have the same letters as in Figure 95: *cl*, the clavicle; *op*, the thumb.**

neck, a little below the hyoid bones. Experiments on living animals, and observations made on those who have undergone the operation of tracheotomy, that is, of having an aperture made into the windpipe between the lungs and the larynx, prove that the voice is formed in that organ.

§ 298. *The Larynx.*—The larynx is a short and wide tube, suspended to the lingual bones, and continuous with the trachea or windpipe inferiorly (*h*, Fig. 111). Its walls are formed of cartilages called thyroid (*t*), cricoid (*c*), arytænoid (*a r*, Fig. 112). The salient angle of the thyroid felt on the surface of the neck in man, still retains the vulgar name of *pomum Adami* (*a*); a mucous membrane, continuous with that covering the tongue, mouth, nostrils, and pharynx, lines its interior, and, extending downwards into the trachea, becomes the mucous membrane of the lungs

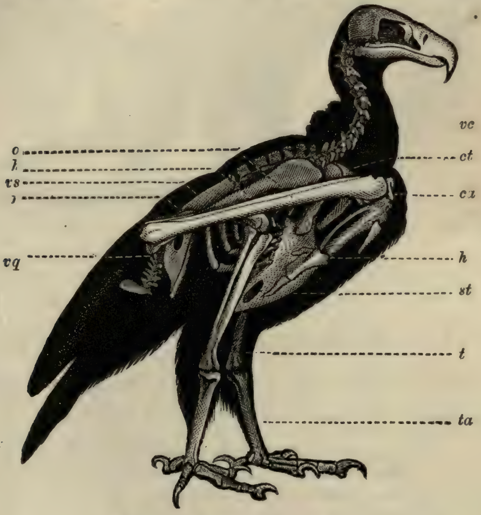

Fig. 109.—Skeleton of the Vulture.*

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* The different bones are indicated by the same letters as in the preceding Figures.

themselves. In the interior of the organ, this mucous membrane forms four folds, two superiorly, called the false vocal cords, and two inferiorly, called the true vocal cords.

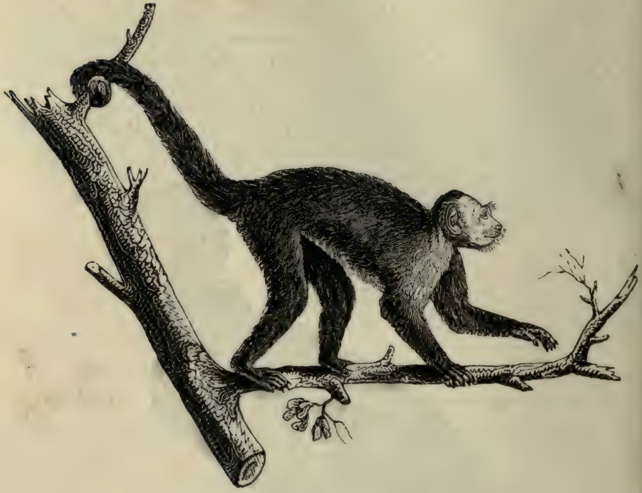

Fig. 110.—White-throated Sapajou, or Sajou, *Cebus hypoleucos.*

It is here, upon the edge of these folds, by the air impinging and causing them to vibrate, that the voice is formed. (Figs. 112 and 113.)

These folds are in consequence called the vocal cords or ligaments of the glottis, the space between the true ligaments being called the *glottis* or *rima glottidis*; the true vocal cords are formed interiorly of folds of mucous membrane, and exteriorly of elastic ligaments, which stretch from the interior of the salient angle of the thyroid cartilage to the arytænoid cartilages. By the muscular apparatus attached to the larynx, not only the entire larynx can be moved up and down in the neck, but these ligaments or true vocal cords can be made tense or relaxed, so as to diminish, enlarge, or all but close the aperture called *rima glottidis*, through which the air must pass and repass in its way to and from the lungs. Between the true and false ligaments of the glottis or vocal cords, on either side there is a cavity, called the ventricle of the larynx. Lastly, superiorly, the upper aperture of the larynx (which must not be confounded with the rima glottidis) is protected by a fibro-cartilage, of a triangular shape, called epiglottis, by means of which, during deglutition, the larynx is still further protected from the accidental passage of food or drink into the air-tubes, the effect of which accident, unless instantly relieved, is suffocation.

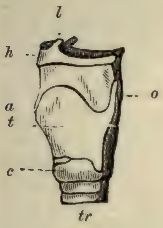

Fig. 111.[*]

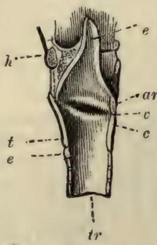

Fig. 112.

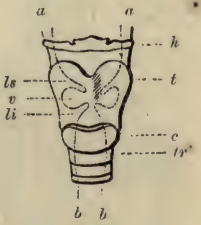

Fig. 113.

§ 299. *Mechanism of the Voice.*—In the ordinary state the air passes and repasses the larynx, and no sound is heard; but when the muscles of the larynx contract so as to modify the vocal cords as to tension, and to affect the diameter of the rima glottidis, sounds are immediately produced. The celebrated Galen divided in a living animal the nerves proceeding to the larynx, and first showed the phenomenon to depend on muscular action influenced by the nerves. By cutting the true vocal cords the voice is destroyed altogether.

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[*] Fig. 111. The male larynx viewed in profile: *h*, hyoid bone; *l*, body of the hyoid, giving attachment to the base of the tongue; *t*, thyroid cartilage; *a*, salient angle of the thyroid cartilage, which may be felt on the surface of the neck (*pomum Adami*); a membraniform ligament unites the thyroid cartilage to the hyoid bones; *c*, cricoid cartilage; *tr*, trachea or windpipe; *o*, posterior wall of the larynx in relation with the gullet.

Fig. 112. Vertical section of the larynx; *h*, hyoid bones; *t*, thyroid cartilage; *c*, cricoid cartilage; *ar*, arytænoid cartilages; *v*, ventricle of the glottis and of the larynx, formed as described in the text; *e*, epiglottis; *tr*, trachea.

Fig. 113. Larynx, front view; the contour of the inner wall is indicated by the dotted lines *aa*, *bb*: *li*, true vocal cords, or inferior; *ls*, false ditto, or superior. The other parts are indicated by the same letters as in the preceding figures.

§ 300. Most physiologists are disposed to think that the voice is solely produced by the vibrations of the true vocal cords acting in the manner of the reed of the hautboy; this would make of the human organ of voice a wind instrument. Others speak of it as if it more resembled the violin, or was a stringed instrument. The human voice, which surpasses all musical instruments, partakes seemingly of the qualities of both kinds of instruments. It has been proved experimentally on the living and dead larynx, that the elastic cords (true ligaments of the glottis) vibrate strongly whilst the voice is being produced, and that the aperture between them becomes much contracted during the execution of acute or shrill sounds; they may even be made to touch for a large part of their course. They differ also in length in man and woman, and in children.

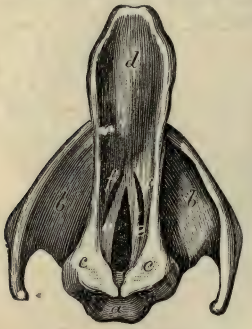

Fig. 114.*

§ 301. The intensity of the voice depends partly on the force with which the air is expelled from the lungs, partly on the size of various parts of the larynx, partly on the facility with which its various parts vibrate. In some mammals, large cells exist, communicating with the larynx, and it is to these cells that the strength of the voice is attributed. This structure is met with in the ass, and more especially in the apes of America, called howlers.

§ 302. The *timbre* (quality) of the voice seems to depend partly on the physical properties of the ligaments of the glottis and walls of the larynx, partly on those of the air-tube following the larynx. The quality, for example, of musical instruments is known to vary much, according as they are constructed of wood, metal, or of other substances; and certain modifications of the voice seem to be referable to a hardening of the tissues composing the larynx, and especially the cartilages. In women and children these cartilages are soft and flexible; whilst in men, and in women with a masculine voice, these cartilages have become ossified.

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* To show the rima of the glottis and the true vocal cords:—*d*, epiglottis; *c c*, the two arytænoid cartilages; *e e*, true vocal cords; between them is the *rima glottidis*.

The form and direction of the passages through which the air passes after having escaped beyond the *rima glottidis*, affect also the character of the voice. Thus, in passing strongly through the nostrils it becomes nasal and unpleasant; the form of the mouth, palate, and velum palati affect, no doubt, the quality of the voice.

§ 303. In birds, as will be afterwards more fully explained, the voice is formed in a supplementary larynx formed much lower down, or in the trachea; in singing birds this organ is very complex.

§ 304. *Modification of the Voice.*—The sounds produced by the vocal apparatus may be divided into the *cry*, the *song*, and the *ordinary* or *acquired* voice.

The *cry* is the only sound which most animals can produce. It is not modulated, and is generally sharp and disagreeable. The cry of man is instinctive, and not generally a voluntary act. It is quite peculiar when it expresses agony or distress. The child can only cry, and it is by imitation of his fellows as he grows up that he learns the art of modulating his voice so as to produce articulate sounds. This *acquired* voice differs from the instinctive *cry*, but is essentially formed in the same way, that is, by sounds whose intervals and harmonic relations are imperceptible to the ear, at least clearly and distinctly. *Singing*, on the contrary, is composed of appreciable or musical sounds, of which the oscillations are regular, and may, as it were, be reckoned by the ear.

§ 305. Man also possesses the remarkable power of articulating the sounds of his voice, and this act is called *pronunciation.*

The organs of pronunciation are the pharynx, the nasal fossæ, and the various parts of the mouth. But man is not the only animal which has this power, although he is the only one who knows how to attach meaning to the words he pronounces, and to the arrangement he gives them; he alone is gifted with the power of speech.

OF THE INTELLIGENCE AND OF INSTINCT.

§ 306. Having examined the organs by which man and other animals acquire their knowledge, there remains the study of the power which determines their actions and the phenomena of the understanding. This branch of physiology having been more cultivated by philosophers than naturalists, we shall confine our remarks thereon to a brief space.

It is man alone who possesses the faculties we allude to in a high order, and it is man who naturally has been most observed in this respect; our comparisons have reference constantly to man; by him we judge of other animals.

§ 307. *Faculties of the Human Understanding.—Impressions* made on the external senses by the external world are transmitted to the brain by the nerves: they are then called *sensations.* Sensation, then, is quite distinct from an impression; it is an impression *perceived;* it implies consciousness; what is not perceived has no existence for us. The perceiving faculty is usually spoken of as the mind, the spirit (*esprit*), the soul; the thinking, perceiving, and reflecting power, conscious of its own independent existence.

§ 308. Over this consciousness we have no power during sleep, but when awake we can direct it to one object to the exclusion of others. When thus forcibly and strongly called on by one impression, pain ceases to be felt, and the external world is no longer observed. This faculty is called the power of *attention*, which varies almost in every individual.

§ 309. The constant relation of certain sensations to certain impressions leads to the inference that the one causes the other; that the one is the *effect*, the other the cause. We arrive at this conclusion by the natural powers of induction. We thus acquire a knowledge of the external world, and we learn to judge by comparison of the different qualities of objects.

Soon the mind does not stop at this point, but proceeds to weigh more and more carefully the impressions and sensations thus received; the faculty of judging and comparing becomes rapid and surer; it is not the senses which are exercised, it is the judgment; the organs of sense require no education. And here man's faculties would stop, were it not for another faculty, by which sensations long since received can be recalled, and compared with each other and with those then and there present.

§ 310. This faculty is the *memory;* by its means we recal the sensations, more or less vividly, more or less accurately, according to our natural powers of perception. The power varies almost in every person. It may be destroyed by disease or strengthened (?) by exercise: active in youth, it becomes dull with age, especially as regards the events of yesterday, whilst the sensations of youth are readily recalled, even in extreme old age. Youth, then, is the age for acquiring knowledge.

Nothing is more capricious than this faculty called *memory;* it would seem as if there were so many distinct *memories*, which different men possess in various degrees. Some have a memory for words, others for dates, others for language, in its largest sense; and by disease one of these memories may be destroyed and not the others. But there exist no good grounds for supposing that there really exist more *memories* than one.

§ 311. By the faculty of *judgment* we compare the sensations derived from all sources with each other, study their relations and draw from them certain conclusions or opinions; and it is this faculty which especially characterizes man from all that lives. By *reflection* he studies his own faculties, and, when it is sound, measures them accurately with others.

§ 312. The *imagination* is a faculty which plays an important part in the phenomena of the human intelligence; it is connected with the power we have of creating signs to represent our ideas.

§ 313. Finally, *the will*, without which our other faculties were given to no purpose; *the will*, by which we seek pleasure and safety, and avoid pain and danger. With this, however, there is joined a tendency to induction, and, superadded as it were, the sentiment of justice, of the beautiful, of pity; in a word, all the moral sentiments so peculiarly human, and which, though general, men possess in such varied degrees.

§ 314. These faculties have strong affinities with others, which may be named *affective*, such as parental and filial affection for our fellow-creatures, &c.; and these, on the other hand, have strong affinities with our natural instincts. In man, these instincts are but little developed, compared with what we find in other animals, in whom they play a most important part.

§ 315. *Principles of Actions.*—The various faculties we have just enumerated are the determining cause of most of our actions.

§ 316. Certain actions, as those of the heart and intestines, called peristaltic, are *automatic*, that is, they are altogether independent of our will. Other movements are semi-automatic, as the respiratory, and the force which determines these seems to reside in the spinal marrow (§ 255).

The effects of habit and of the association of ideas form an interesting subject of psychological inquiry; but for this we have no space, but must remain content with merely pointing out the analogy between the acts resulting from these and the operations of instinct.

§ 317. *Faculties of Animals.*—Contrary to what might have been expected, the study of animal instinct is more difficult than that of the human understanding; we have, in fact, no means of knowing how they think and feel; we can judge only by the results, that is, their actions.

§ 318. All animals feel; but in the lowest it is not easy to perceive that the sensations they experience lead to any act of judgment or reflection: they move to avoid an obstacle, and that is all. The faculties of *relation* seem limited to this in the infusoria and in zoophytes. But as we ascend in the scale, acts appear in the history of animals, so complex and so appropriate, as to force us to admit an admirable instinct to preside over these, and even a degree of intelligence resembling, however distantly, our own. The natural history of the beaver, the bee, and the ant, are singularly instructive on this point; whilst the intelligence of the dog, the elephant, and the ape, has at all times attracted the notice of man.

§ 319. *Instincts of Animals.*—The character which especially distinguishes instinct from reason, is, that instinctive actions are not the result of experience or of previously acquired knowledge through the senses, whilst those of reason can be readily traced to that source. In man, the reason takes almost wholly the place of instinct; in animals it is the reverse. As one of the simplest examples of instinct, we may cite the case of ducklings hatched and brought up by a hen. In spite of every effort made by the supposed parent, the duckling at once seeks the water, and boldly plunges into a medium of which it has no experience, and into which its adopted parent dare not follow.

As examples of instinctive acts of extreme complication, we may cite the labours of the bee. Now bees require neither models, nor instruction, nor experience; they are self-taught, and from generation to generation they labour in the same way; but they continue also to labour (and this is why we say "blind instinct") when their labours can be of no avail. Such labours cannot be ascribed to any acts of intelligence, but resemble rather those which lead the infant to the breast of its parent.

So varied are the instincts of animals, that we could only venture in a brief manual such as this to speak of a few—these we shall select from amongst the more remarkable.

§ 320. The principal instinctive actions may be arranged in three classes, according as they refer to the preservation of the species, to that of the individual, or to its relations with other animals.

§ 321. Of the instincts bestowed on animals by nature, none is more remarkable than that inciting them to live exclusively on certain substances. Some of the simplest animals are without instinct, and swallow whatever comes near them: such is the case with various zoophytes; but it is quite otherwise with most, which refuse obstinately all sorts of food but one. Some live exclusively on animal food, others on vegetable; others only on certain plants, or the leaves and fruit of but one plant, showing an indifference for all others; and what is most remarkable is, that at a certain stage of their growth they will abandon this kind of food for another, with the use of which they were previously wholly unacquainted. Thus certain insects carnivorous in the larva state, become phytivorous when perfect: and frogs, which when tadpoles are vegetarians, become carnivorous as frogs.

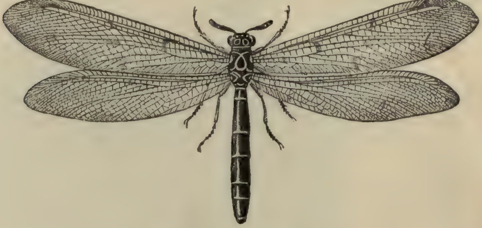

Fig. 115.—Ant-lion.

§ 322. With the instinct, nature of course gives the ability to gratify it.

Thus the larva of the ant-lion (Fig. 116), a small insect resembling an ephemera, preys on ants and other insects, of which it sucks the juices; but being slow of foot, it is forced to spread traps for the capture of its prey. It digs in the sand a small pit, in the form of a funnel (Fig. 117), in the bottom of which it conceals itself, watching the moment when its prey may fall unawares into it. Should the fall not be effectual, it stuns its victim by throwing grains of sand at it, by means of its mandibles. Its mode of procedure in digging the pitfall is equally curious. After having examined the ground, it traces a circle; placing itself within this circle, it commences digging, throwing out the sand from the excavation as it is being formed; this is done by means of the head. Thus it continues turning itself round within the circle traced, until it returns to the point from which it started, where, changing sides, it repeats its labour until the pitfall be complete. Should it meet with a stone difficult to move, it leaves it for awhile, to return to it when the rest of its work has been accomplished; its whole efforts are now directed to remove the stone, but should these fail, it abandons the entire enterprise, proceeding elsewhere to break up fresh ground. Lastly, it repairs carefully any damage done to the walls of the pitfall by accident.

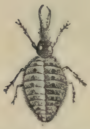

Fig. 116.—Larva.

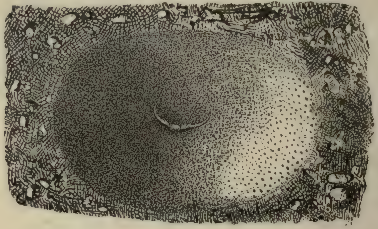

Fig. 117.—Pitfall of the Ant-lion.

Certain spiders, as is well known, spread nets still more curious, to catch flies and small insects. The disposition of the thread of the web in some is without regularity; in others, as in the web of the *Epeira Diadema*,* it presents the utmost elegance of arrangement. Some enclose their victim, in addition, with threads of the web, so as to afford them time to pierce it with their venomous claws.

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* *Aranea Diadema*, Lin.

The Archer of the Ganges, a fish living on insects, spirts water on those he sees on aquatic herbs, and is said seldom to miss his prey, even at the distance of several feet.

Finally, to instinct must be ascribed most of the wiles practised by quadrupeds during the chase of their prey.

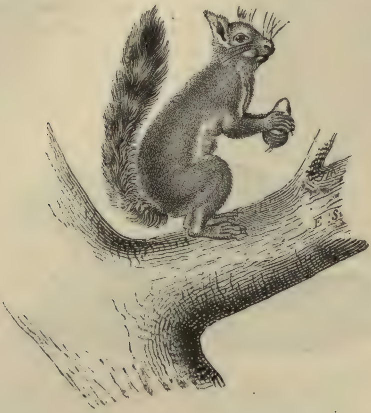

Fig. 118.—Common Squirrel.

§ 323. To the same class of instincts must be referred the cumulative or store-forming habits of certain animals. The common squirrel furnishes us with an example of this propensity to lay up a store of provisions against a scarcity, to be dreaded or expected in winter; but the propensity exists where no change of season indicates the reasonableness of such an event. The young commence laying up store of provisions during summer in hollows of trees, which they readily find in winter, even though concealed with snow. The *Lagomys pika*, a Siberian rodent, not only lays up a store for the winter, but turns the grass into hay, exactly as our farmers do, before it stores it. Under each magazine of hay, prepared in fine weather with the greatest care and foresight, he digs a passage to his burrow, that he may visit each in turn, under shelter and under ground, protected from accidents and sheltered from the inclemency of the weather. The bee, of which we shall presently speak, labours in this direction, laying up ample store of provisions for winter.

§ 324. Amongst the preservative instincts, as they may be called, is the art of constructing dwellings without either model or instruction. The silkworm spins a cocoon, in which it remains as a larva, until ready to become a butterfly. The rabbit forms its warren, and the beaver its well-known habitation. The hamster (Fig. 119), a small rodent analogous to the rat, met with in the plains from Alsace to Siberia, and which is so injurious to agriculture, constructs a dwelling with two issues or exits; the one oblique, by which it throws out the loose earth produced by its excavations; the other, perpendicular, is the way by which it enters and leaves its dwelling. These galleries lead to a certain number of circular excavations communicating with each other by horizontal passages; one of these cells, furnished with dried grass, is the dwelling of the hamster; the others are intended to serve as magazines of provisions, which it collects in considerable quantities.

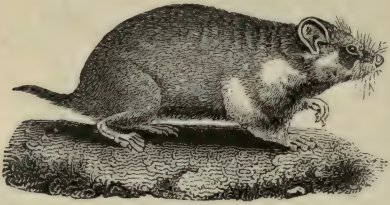

Fig. 119.—The Hamster.

Some spiders (*mygale*) construct works like those of the hamster, but more complicated; for they not only construct a vast and commodious dwelling, but know how to shut it in by means of a covering or doorway, furnished with a hinge. On the side opposite to the hinge are a number of small openings, into which the animal, introducing its claws, holds the covering secure when an enemy attempts to open it. The exterior of the doorway of this den, as it may be called, is left rough, like the neighbouring soil, so as to elude observation; the pit forming the den is dug in argillaceous earth, and lined interiorly with a kind of extremely consistent mortar, and a lid or covering is worked with alternating layers of miry earth and threads reunited into a tissue, made to fit exactly and to open only outwards. The hinge supporting this covering is formed by a continuation of the filamentous layers proceeding from a point of its contour upon the walls of the tube situated beneath it, forming there a pad or hood, performing the office of a mantle-tree.

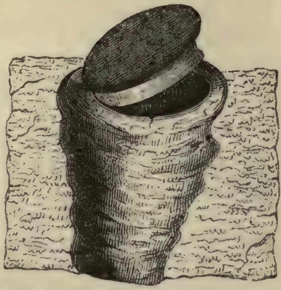
Fig. 120.—Nest of the *Mygale*, or Bird Spider.

Among insects also may be observed many remarkable instances of singular instincts in the construction of dwellings. The larva of a small nocturnal butterfly, the *tortrix viridissima*, is one of these; it lives on the oak, rolling up its leaves and connecting them together with threads. Others, as the cloth moth, a small grey and silvery papillon or moth, which, when in the larva state, rapidly breaks up woollen stuffs, forming galleries in the thickness of the web or cloth. With the hairs or wool thus detached it forms long tubes as a dwelling; and what is singular is, that when this becomes too small to contain it, it breaks it open and adds to its length.

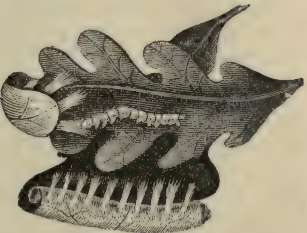
Fig. 121.—Nest of the *Tortrix;* Oak-leaf rolling Caterpillar.

Hybernating animals show singular instincts tending to their preservation: they prepare a winter dwelling, and shut it in, as if conscious or aware that they would not require to leave it for a long period; also to protect them from the access of cold and enemies. This is the case with the marmot exhibited in the streets by Savoyard boys.

§ 325. A third class of instinctive faculties, which, like the preceding, have a reference to the preservation of the individual, but which at other times seem combined with the faculty of securing to the young conditions favourable to their existence, is exhibited by those animals which undertake distant journeys: sometimes even to change their climate periodically; occasionally they merely leave the district when they have exhausted the provisions it furnishes to them; sometimes it is the cold of winter which urges them towards the south, or the heats of summer which drive them to the north. But these journeys are always undertaken before any atmospheric change appreciable by us happens, to warn them of a necessity for such a change; or, in other words, their instinct leads them to perceive the coming event, and directs them at once to the object sought, the region they aim at, without the least hesitation or error. They unite in bands, and thus proceed on their journey.

The apes of the New World change their habitat irregularly; they exhaust the resources of a district, and proceed in search of another with loud cries, carrying their young on their backs.

The lemmings also undertake distant journeys, seemingly in an irregular manner, and for reasons which man cannot discover. They inhabit the shores of the Icy Sea, and descend occasionally from the mountains in innumerable bands. These migrations, fortunately for the inhabitants of Sweden and Norway, happen only about once in ten years; for the lemmings travelling in straight lines, and thus crossing rivers, rocks, and mountains, destroy all vegetation, even to the roots and grains. Nothing diverts them from their course but smooth walls, which they cannot cling to.

In general such journeys are periodic. A small rodent, resembling the lemming, annually leaves Kamtschatka for the west; they march in straight lines, and are so numerous that when they reach the banks of the Ocholsk and of the Joudoma, after having traversed 25 degrees of longitude, a single column will occupy two hours in defiling. In October, they return to Kamtschatka, and their return is a *jour de fête* for the inhabitants, for the number of the carnivora which follow them is so great as to furnish an abundance of valuable furs. At the Cape of Good Hope and in North America are also met with, in spring time and autumn, vast herds of antelopes and deer, migrating to great distances.* But it is chiefly in the class Birds that the more remarkable instances of this migratory habit are found. A great number of these animals pass and repass from Europe to Africa so regularly that one may almost name the day of their probable arrival. The swallow comes in spring and departs in autumn. At this season they unite in troops, and may be seen collected on some prominence of the Mediterranean shores, watching, as it were, the favourable moment for the commencement of their journey. They proceed sometimes as far as Senegal. The quail also seeks in the milder regions of Africa and Asia Minor a winter residence; and many northern birds migrate annually towards the South, to pass the rigorous season in milder climates, returning towards the polar regions with early spring. The same instinct exists in fishes; the salmon, herring, tunny, &c., offer examples sufficiently well known.

§ 326. No less curious are the instincts which lead insects and other animals to provide for the preservation of the young. The tedious process of incubation or hatching the eggs; the care bestowed by the parent on the young so soon as they appear; the selection of the *locale;* the construction of the nest; the kind of education which some give their young; the forethought which provides for the young food in abundance the moment they require it, added to the love of offspring so strongly shown in many animals, must always excite in every reflecting mind the utmost admiration of the boundless power and knowledge and wisdom of the great Author of nature. These instincts extend to woman herself, and develop in her at once all the fondness of a parent and the sagacity of womanhood.

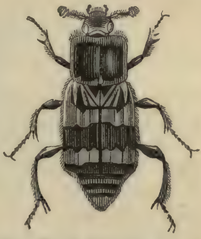

Fig. 122.—Necrophore; the Sexton Beetle.

§ 327. As many insects never see their young, these wonderful acts arise only from instinct: many place by the side of the larva, food adapted for its nourishment, not such as they themselves use. The necrophore (Fig. 122), Sexton Beetle, often met with in the fields, buries the carcase of a mole or some other animal near the place where it deposits its eggs, that the young when they appear may have an abundant supply of provisions. They live on putrid meat like the parent; but the pompiles, insects allied to the wasp, live, when adult; on vegetable food, as larvæ on animal substances. They thus provide for the young a food they do not themselves use; they place near the nest the body of a spider or of some caterpillar, which they have pierced with their sting. The xylocopa or carpenter bee (Fig. 123) has similar habits, and hollows out in timber a series of cells, serving at once as nests and storehouses for its larvæ.

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* These migrations of the Antelope in Southern Africa appeared to me to be chiefly regulated by the condition of the pasture.—R. K.

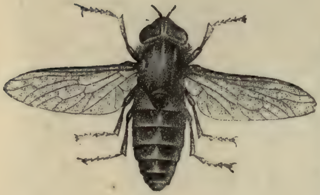

Fig. 123.—Xylocopa (Carpenter Bee).

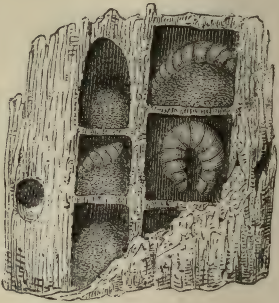

Fig. 124.—Nest of the Xylocopa.

§ 328. The adult bird seldom provides any nest or dwelling for itself; it is for its feeble and tender young that it labours with such skill and perseverance in the construction of a dwelling for them when they most require it. These nests, which vary with the species, are yet as it were identical as regards any species, and are uniformly constructed in the way best befitting the young of that species. They vary in their position, in forms, and composition, but most have a hemispheric form, the exterior formed of stalks and grass and herbs, the interior of soft downy substances, as moss (Fig. 125); but at times they are more complex. A well-known instance is that of the baya of India, a bird of the nature of our bullfinch; the nest it forms resembles a bottle, and is suspended to the branch of a tree, so that neither apes, serpents, nor even squirrels can reach it; the entrance to the nest, moreover, looks downwards, so that the bird can only enter from below, and flying. It has two chambers, one for the male, the other for the female. Another nest equally curious is that of the Sylvia sutoria (Tailor Bird), which converts the cotton of the cotton-tree into threads, and with these sews together the leaves so as to form a nest.

Even some fishes construct a kind of coarse nest, in which they deposit their ova; but it is amongst insects that the constructive power is the most remarkable; and to this we shall return in describing the nests of bees and wasps, and we shall therefore conclude this brief sketch by a single example taken from the class of solitary insects.

The Xylocopa violacea (Violet Carpenter Bee) is allied to the family of bees. This animal (Fig. 123) hollows out in the timber of the hedge-rows, of fruit-trees, and of vine poles, oval holes, which at first advance obliquely, then curve downwards, and descend vertically for a foot or more: in thus tunnelling the wood, the xylocopa takes care to preserve and collect together the *débris*, with which it afterwards constructs partitions, thus forming cells for lodging the larvæ

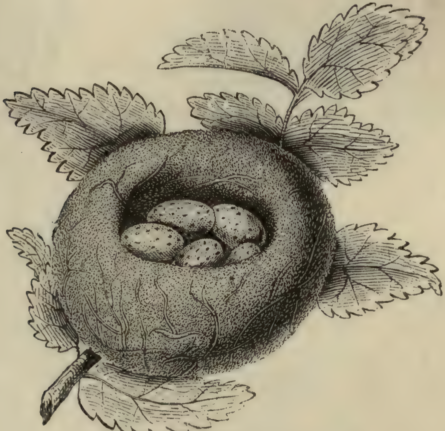

Fig. 125.—Nest of the Goldfinch.

and their food; in each cell is deposited an egg, and a quantity of vegetable fodder as food for the young so soon as it may be hatched.

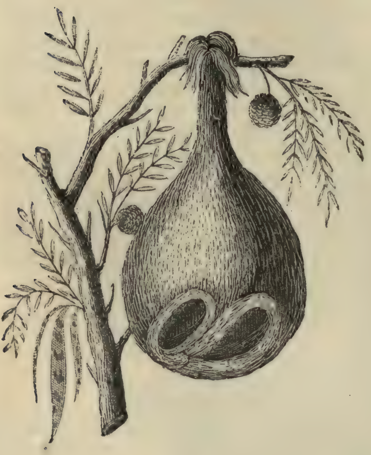

Fig. 126.—Nest of the *Baya.*

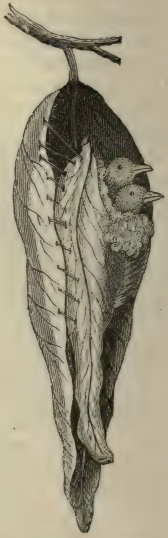

Fig. 127.—Nest of the *Sylvia Sutoria,* or Tailor Bird.

§ 329. By instinct, animals lead a solitary life or live in groups; and these groups unite for mutual defence. Each species has its own habits and its own relations with other animals, with which it consorts or avoids or pursues. These associations are sometimes permanent, at others only temporary. The hyæna and wolf unite in groups only when pressed by hunger. Swallows also assemble for the purpose of travelling. Still more remarkable is the so-called pigeon of America. They collect in almost countless millions. The celebrated American ornithologist, Wilson, calculated at 2,000,000 a single band which he saw in Indiana; and Audubon relates that one autumn day he left his house at Henderson, on the banks of the Ohio, and whilst traversing the uncultivated plains near Hardensburgh, he saw these wild pigeons in considerable numbers, flying from north-west to south-east; as he journeyed on to Louisville the flock of birds became more and more numerous, until the light of midday was obscured as in an eclipse; the droppings fell like snow; before sunset he arrived at Louisville, a distance of fifty-five miles, but the flight of the migratory pigeons still went on; this phenomenon continued for three days; the droppings from the birds formed a distinct layer on the soil; forests were stripped of their leaves, and sometimes destroyed, and the traces of their passage will remain for years.

Fishes and insects are also gregarious, the herring for example, and locust; the former assembling in vast shoals, and the latter in such numbers as to devastate a country.

§ 330. The *Psittacus infucatus* is described by Levaillant as assembing in numbers towards evening to bathe and sport in some limpid stream, returning to the woods so soon as the evening pastime is finished. It is this instinct of sociability which brings together the warren rabbit and the prairie dog of America, a small rodent, with habits resembling generally this class of animals. But it is chiefly in the beaver, the wasp, bee, the ant, that this sociable instinct shows itself in its utmost development; that is, instinct directing all towards some common labour.

§ 331. The Canadian beaver is of all animals the most remarkable for its sociability and instinctive industry. During summer it leads a solitary life in burrows dug by the banks of some lake or river; but, when winter approaches, it quits its burrow to assemble with its fellows to construct in common with them its winter dwelling. In a spot remarkable for its solitude, a group of two or three hundred assemble, and display all their architectural industry. Here they select a stream of sufficient depth as not to freeze throughout during the winter. They begin by forming with branches of trees, interlaced, the intervals being filled up with stones and mud, a sloping dyke, with the convexity towards the stream; this dyke they crisp entirely with a thick and solid covering. The dyke is generally eleven or twelve feet at the base. It is strengthened annually by new works, and ultimately becomes covered with a thick vegetation. Thus is provided a pool of stagnant waters, or at least waters but little disturbed, in proximity with their dwellings.

When the dyke is finished, or when the waters are smooth, such a preliminary work is not required. The beavers separate into a certain number of families, and commence constructing their huts, or repairing those already built.

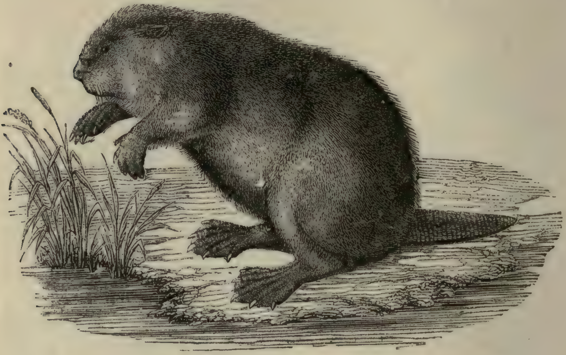

Fig. 128.—The Beaver.

These cabins are raised against the dyke or on the edge of the waters, and are of an oval form; they are constructed in the same way as the dyke itself, of branches of trees, strongly cemented together by a kind of puddle-work. For this purpose they use the earth dug from under the wall or the banks, and work it with their feet; it does not appear that the tail is employed for this purpose. The branches of the trees, no matter what be their size, are readily cut through with their sharp rodent teeth; and when a larger trunk is required so as to intercept the stream, they, working in groups, divide it so that it shall fall in the most favourable manner to be floated to its destined resting-place. Their cabins have two floors, one under water, the other above; the entrance and exit are by the chamber which is under water. Finally, all these works are carried on at night, and with extreme rapidity. When the proximity of man hinders the beaver from uniting in numbers sufficient to carry on those works requiring the association of many, they no longer build huts; but the instinct of construction remains even in captivity, as has been seen in beavers confined in the Garden of Plants, in Paris, as shown by their collecting bits of wood for a work which was not to be carried through.

Perfect societies, like the one just described, are rare amongst birds; yet we have in the *Loxia socia*, a kind of sparrow of the Cape of Good Hope, a specimen of the sociable instinct. These birds construct their nests under a roof-work common to the whole colony (Fig. 129).

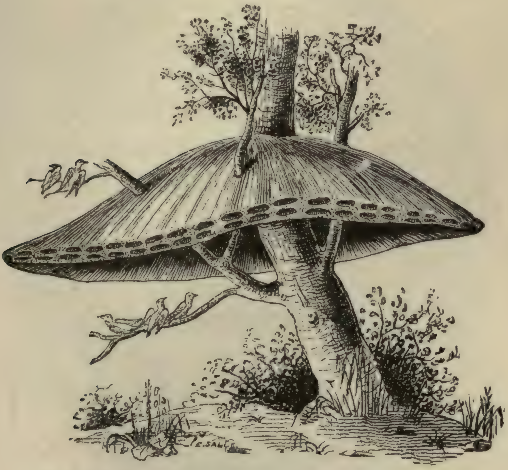

Fig. 129.—Nest of the Republican, or Sociable Grosbeak.

The nests of wasps surprise us by the regularity and perfection of their construction. Wasps detach, by means of their mandibles, parcels of old wood, which they convert into a kind of paste resembling pasteboard, with which they construct rows of hexagonal cells; these rows are placed parallel to each other, and at certain distances supported by pillars, which serve also to suspend them; finally, the whole is placed sometimes in the air, at others in the hollow of a tree, or even underground, according to the species, exposed or enclosed in a common covering (Fig. 130).

§ 332. Community of labour is the great feature in the history of the bee; but the bee, in its relations to the working bee and the queen bee, shows other instincts not less remarkable.

The domestic bees, originally from Greece, but since spread all over the world, live in colonies composed of ten to thirty thousand neutral or working bees, of from six to eight hundred males called drones, and of a single female, which seems to reign as queen. They establish their dwellings in the trunk of some ancient tree, or in the hive which man prepares for them; and to the working bees belong the labours to which the society owes its existence. Of these, some are the wax-gatherers, which go abroad to collect the food and the materials for the construction of the comb; to others, called nurses, is assigned the task of watching over the young.

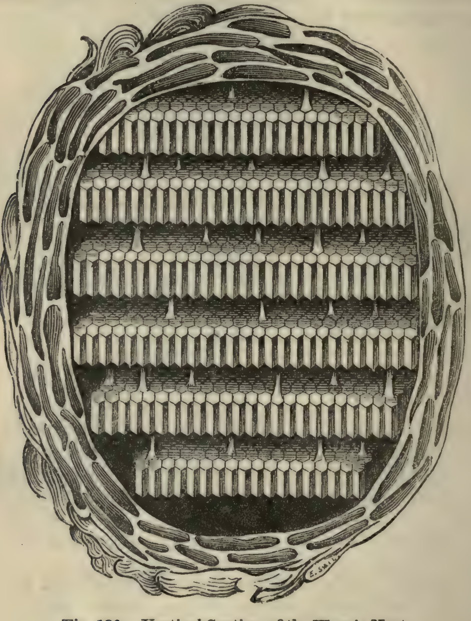

Fig. 130.—Vertical Section of the Wasp's Nest.

The working bee for collecting the wax enters a flower, the stamens of which are loaded with pollen. This dust attaches itself to the brush-like hairs covering the body of the bee, when, by rubbing itself with the brushes with which the tarsi are furnished (Fig. 131), the insect collects it into little parcels, which it places on small palettes, hollowed out on the surface of its hind limbs (Fig. 132). By the aid of mandibles the working bees also detach from the surface of plants a resinous matter called *propolis*, and with it they also charge their little baskets. Thus loaded the bees return to deposit in the interior of the hive the materials they have collected, to set out again in quest of more. The labour in the interior of the hive is more complex. They begin by closing with the propolis every fissure in the habitation, leaving but one opening, of no great dimensions. They next proceed to the formation of the comb intended to lodge the young, and to serve as store-cells for the provisions of the community. The comb is made of wax, found in various plants, but which is also secreted by the bees themselves in organs situated under the abdominal rings. These combs, or rows, are composed of two layers of hexagonal cells, with a pyramidal base, and suspended perpendicularly by one of their sides. Empty spaces are left between them, to permit of the bees reaching every part. The cells are arranged horizontally, and are open at one of their extremities; they are all of nearly the same dimensions, but some few are called royal, being much larger than the others, almost cylindrical, and are destined to contain the female larvæ.

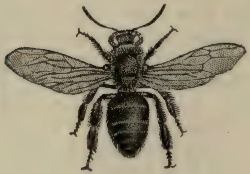

Fig. 131.—Working Bee.

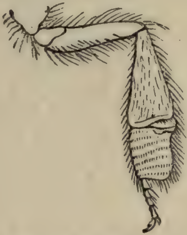

Fig. 132.—Hinder Foot and Leg of the Bee.

Bees enclose with a covering of wax the cells containing the honey, and they take means to strengthen the combs when any accident threatens their safety. The males or drones do not share in these labours, and when they are no longer of any use to the community, the working bees sting them to death. This carnage takes place between June and August, and it extends even to the larvæ and nymphæ of the males.

The female does no work; she is always pampered and attended to with the utmost care by the rest of the hive. From the time she begins to lay eggs, she becomes for the whole colony an object of the utmost respect, and she permits no rival in the hive. Should one accidentally appear, a mortal combat ensues, which terminates fatally for one, the other remaining sovereign of the hive. So long as she is shut up in her habitation she lays no eggs; but should fine weather appear, she leaves the cell and the hive a few days after her birth, and ascends in the air out of sight with the males. But she soon returns to the hive, and commences laying eggs forty-six hours afterwards. These eggs she deposits in cells already prepared for their use. During the first summer these eggs are not numerous, and they become merely working bees. During winter she ceases to lay eggs, but so soon as spring-time returns her fecundity becomes extreme, and in three weeks she lays more than twelve thousand eggs. Towards the eleventh month of her existence she begins to lay eggs which produce the *bourdons*, or males, along with others which belong to the working class; those of the female come a little later. In three or four days after the laying, the eggs are fully hatched, and there comes forth a little larva of a whitish colour, which, having no feet, is quite helpless; but the working bees provide amply for it, and furnish it with a sort of *bouillie*, of which the qualities vary with the age and sex of the individual for which it is intended; and at the moment of the transformation of the larva into a nymph, they shut it into its cell, closing it in with a covering of wax. Five days after the birth of the larva of a working bee, its nurses enclose it thus in its cell. It now spins around its body a web of silk, and at the end of three days changes into a nymph. Finally, after having remained under this form during seven days and a half, it undergoes its last metamorphosis. The males do not attain their perfect state before the twenty-first day from the birth of the larva, whilst the females undergo their last metamorphosis on the thirteenth day. By varying the food given to the larvæ, the working bees, or nurses, can change them from working bees or neutrals into females or queens. Should the queen bee be lost, the working bees immediately set to work and break down several ordinary cells to convert them into a royal cell. The larva of one of these cells is now fed so as to become a queen bee. When a young queen bee has finished its metamorphosis, and gnawed through the covering of the cell, a great agitation may be observed in the hive. On one side may be seen working bees, which strive, as it were, to retain her in the royal cell by shutting up all access to it; on the other hand may be seen the old queen bee approaching to endeavour to destroy her, in which attempt she is obstructed by hosts of working bees, which endeavour to obstruct her progress, but make no attack on her. At last, as if in a passion, she quits the hive, and with her the greater part of the working bees and males over whom she presided. The young bees, too feeble to leave, remain with the young queen bee, which now becomes the sovereign of a new colony, occupying the seat of the original one. The hive which has left with the old queen remains together, and forms a new society, which, recommencing again all the labours we have just described, furnishes, after a certain time, a second swarm, whose emigration is determined by the same causes as those which gave rise to the first. A hive gives off several swarms during a season, but the last are always feeble. The colony sometimes breaks up on the death of the queen bee, the attacks of enemies, or the weakness of the swarm; but the bees thus dispersed seek shelter in other hives, where they are uniformly destroyed by the proprietors of the hive, for no strange bee is admitted into a hive in which it was not born. Sometimes, also, a whole colony attacks another, and robs it of its stores of provisions.

§ 333. This pillaging instinct on the part of bees resembles what we find takes place in some other insects, but which is manifested in a different manner. Animals of a different species are captured and reduced to slavery. The natural history of ants gives us the example.

These interesting insects live in colonies, composed of males, females, and labourers. These latter are steriles, or neutrals: they do all the necessary work, and are provided with strong mandibles, a large head, but are without wings. Thus they may be known from the other ants. Each species has its own mode of procedure. Some build their houses in earth;

others in wood. The first dig in the soil a number of galleries, disposed in floors. The *débris* rejected forms a hillock, in which the indefatigable ants construct other dwellings, also in floors or stages; but sometimes, with the earth thus thrown out, they construct galleries along branches of trees. The ants which establish their dwellings in trees, attach themselves to one going to decay, and already attacked by other insects. With their mandibles they vigorously assail the timber, forming it into galleries and dwellings, and supporting these galleries with columns wherever they may be required. Should any accident happen by the falling of these beams, the working ants hasten to repair the damage, to drag their comrades from under the ruins, and to place them in a secure quarter. The males and females take no part in these labours. The first remain but a short time in the hillock, and perish shortly after leaving. The females, which have left with the males, after losing their wings, are brought back to the ant-hillock by the working ants, placed in retired cells, where they remain prisoners, being all the time carefully fed and attended to by the labourers. So soon as they have laid an egg, it is laid hold of, and removed to a separate apartment or cell, each to its own;—the egg which is to give origin to a female to its own cell, and that which in time will produce a labourer, to its particular dwelling-place. The larvæ are attended and fed with the greatest care with their appropriate food, and carried out in fine weather to bask in the sun. Whilst so exposed they are defended from their enemies, and carried back in the evening to their cells, which are kept in the very best order. Ants lay in no stock of provisions, but seek day by day what they require. Whilst some are occupied with the care of the buildings, others proceed in quest of food. They attack the *pucerons* (grubs), which on being pressed by the feet of the ant, give out a drop of sweet liquid, which the ant carries off. But some are not content with this, but carry with them the insects (*pucerons,* or grubs) to the hillock, and retain them there, as farmers do milch-cows. Two neighbouring or rival hillocks have been seen to fight for the possession of these *pucerons*, and the conquerors have been seen to carry off their prisoners with the same care that they bestow on their own larvæ. Finally, that which is most singular in the history of the ant, is still to be told. These industrious labourers seem occasionally to get tired of their labours, as if they wished to enjoy a little repose. In this case they make war on feebler species, to procure the larvæ and the nymphs, transport them to their hillock, and charge the slaves they have thus procured with all the labours of the community.

§ 334. The instinct of society is in some animals united to another natural tendency, less striking, but perhaps of more importance to man; we allude to the disposition to obedience in a whole flock to obey a chief, and which seems connected with the instinct of imitation. This instinct is remarkable in the horse and in apes.

§ 335. *Faculties of the Understanding in Animals.*—Instinct, no doubt, is the determining cause of most of the actions of animals, properly so called; but some of them seem to possess a certain amount of memory, judgment, and even the faculty of establishing certain reasonings but little complicated.

The faculty of *memory* is obviously possessed by many animals: the horse, the dog, the elephant, remember kindnesses, and are not forgetful of ill-treatment. Even fishes seem to have this faculty, for eels have been taught to recognise the voice of their keeper.

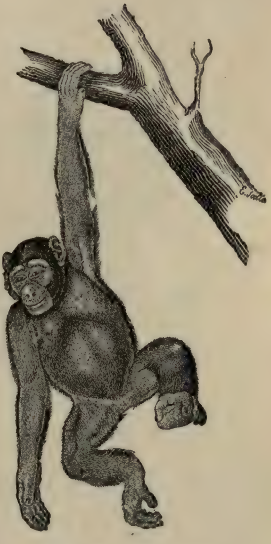

Fig. 133.—Chimpanzé.

§ 336. It is even impossible to deny reasoning powers to some animals. Thus, the dog confined in a wooden cage will continue to attack the bars, evidently hoping to destroy them; but he speedily ceases to attack them if made of iron. When the dog sees his master take his hat, he prepares himself for the journey, evidently anticipating what will, or may, happen; nor can we ascribe to any other faculty but that of reason the conduct of the watch-dog, which every night freed himself of his collar, and making for the fields, attacked and slaughtered the sheep; returning after the butchery, he washed from his mouth and throat the proofs of his guilt, and reached his home, replacing the collar, and lying down on the straw, reposing as if nothing had happened.

A still higher development of this faculty appears to exist in the oran and chimpanzé. A young one of each of these species (Fig. 133) attached itself to the keeper, and assumed on a variety of occasions all the habits of a child. It reached by means of a chair the lock which secured it in its cage; on this being removed by the keeper, the chimpanzé put another chair in its place. In this action we see not only the power of acquiring knowledge by experience, but also the ability to generalize.

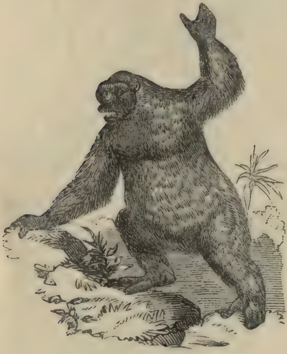

Fig. 134.—The Gorilla.†

§ 337. In this approach to human intelligence in the lower animals, the quadrumana and carnivora are foremost;* after these come the pachydermata, as the elephant and horse; next, the ruminants; last of all mammals, the rodents, as the beaver, squirrel, &c. The squirrel cannot be taught to recognise its own master; the ruminant recognises its master, but a change of clothes is sufficient to make it mistake him for a stranger. Thus, a bison, in "the Garden," obeyed perfectly its master, until he happened to change his clothes, when it attacked him impetuously; on assuming his former dress, the bison again recognised him as its master. Two rams living together in harmony, will, on being shorn, attack each other as if they were perfect strangers. The sagacity of the dog and elephant is well known; so also is that of the ape, but this is confined as regards it to youth, for with age it progresses not, but often becomes morose and savage.

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* No animal lower than man seems to me to possess the faculty of *generalization.*—R. K.

† First described by M. Isidore Geoffroy (St. Hilaire) in such a way as to leave nothing to be desired. A controversy was raised some time ago in this country respecting the resemblance of the brain of the gorilla to the human brain. It was a controversy about words. They strictly resemble each other in all material points. The oran outan and chimpanzé seem to me to stand higher in the scale of being than the gorilla, which is a West African species, and dangerous to meet. Properly speaking, there are no four-handed animals.—R. K.

§ 338. Some animals possess the power of intercommunication, by means of which they express what they feel, and make their feelings known to their comrades. Thus, certain mammals and birds, which live in groups, sometimes place a sentinel, which by peculiar cries warns the troop of the approach of danger: the marmots and the flamingo do this; swallows seem also to have the power, by a peculiar cry, of collecting together for mutual defence all the neighbouring swallows, more especially when there is danger to their young; and the observations made on bees by Huber, Latreille, and other naturalists, leave little doubt that these insects have the power of intercommunication. This is seemingly not effected by any sound, but by touching each other with their heads and antennæ, and on this being done, thousands will crowd to the point of danger. In the obstinate wars which one colony of ants will sometimes carry on against another, individual ants have been seen thus to give such signals as to change the route of a whole army; and observers worthy of every credit assure us, that individual ants have been seen to quit the main body, and repairing to the hillock, return with strong reinforcements.

§ 339. But if the faculties we have spoken of explain more or less satisfactorily the actions of man and animals, there are others which, in the existing state of our knowledge, admit of no explanation, and which lead us to suppose that such animals possess organs of sense of a kind unknown to us. Neither instinct nor intelligence can explain the course of the swallow and carrier-pigeon, transported hundreds of miles from their locality, towards which they fly, when let loose, in a line as straight as if it lay before their eyes. The dog and horse seem to retrace their course, when lost, by the ordinary senses; but this cannot be the case with the carrier-pigeon flying in a straight line from Bordeaux to Brussels.

§ 340. *Relations between the Intellect and the Brain.*—We know nothing of the cause why certain intellectual and instinctive faculties are present or absent in certain animals, nor of the mechanism by means of which the faculties are exercised; all we know is, that it is by means of the nervous system that all these faculties are exercised. When the action of the brain is suspended, we lose the consciousness of our existence, and with it all the intellectual faculties: the organic life then alone remains: thus the brain is proved to be the organ of all intellectuality, and the centre of "the life of relation." Since nothing is known as to the nature of thought, we are of necessity compelled to refer it to an immortal principle in man called the soul; in other animals, the vital principle seems to take its place.

§ 341. The brain being admitted to be the instrument by which the intellectual faculties are exercised, it is natural to suppose that its structure, or at least its structural arrangements, will be modified in different animals; and this is what we find takes place.

§ 342. Generally speaking, the power of an organ, all things being equal, is in the direct ratio of its bulk; and to a certain extent this holds true, when we compare the brain of man with the quadrumana, carnivora, and rodents; in fishes, animals low in the intellectual scale, the brain is comparatively very small and simple.

This led to the idea, that the amount of intelligence in man and animals might be measured by the size of the brain, and the facial angle, invented by *Camper*, was used with this view.*

A horizontal line (*c d*, Fig. 135) is represented as passing by the auditory canal and floor of the nasal fossæ; a second line, *b a*, is let fall on the first so as to intersect it; the angle formed at the point where these lines intersect each other will be found to measure, by its approach to a right or an obtuse angle, the development of the cranium anteriorly, as compared with the size and protrusion of the face. The angle is called the *facial* angle of Camper.

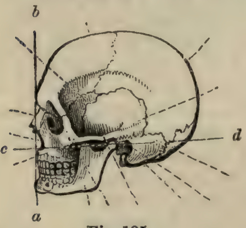

Fig. 135.

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* It is calculated to show the relative size of the cranium as compared with the face; but Camper did not employ it with this view.—R. K.

In the antique busts, and in some living heads, this angle amounts to a *right angle;* but in most European crania, it does not exceed 80° (Fig. 135); in negroes, about 70° (Fig. 136); in various kinds of apes, from 65° to 30° (Fig. 137); in the lower mammals it becomes still more acute, as may be seen by referring to Fig. 138; finally, in birds, reptiles, and fishes, it becomes still more acute than in mammals.

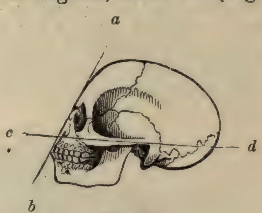

Fig. 136.

This coincidence between the inclination of the facial angle and the intellectual faculties, did not escape the ancient sculptors; and they even exaggerated the angle in some of their busts.

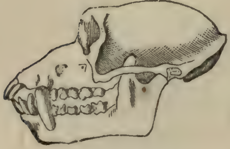

Fig. 137.—Cranium of the Barbary Ape.

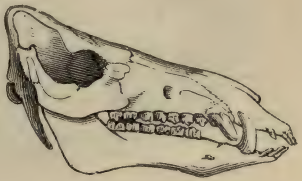

Fig. 138.—Cranium of the Wild Boar.

[But it is not safe, in a scientific point of view, to attach much importance to such measurements, for the presence of the frontal sinuses, so large in many animals, as in the owl and elephant, and even in man himself, may lead to grave errors in respect of that which is really aimed at,—namely, to discover the ratio of the *area* of the cerebral cavity to that of the *face;* and by inference, the relative size of the brain, or of all the central organs situated within the head, to the capacity of the cavities for containing the organs of sense.—R. K.]

[§ 343. Daily observation shows how variously the intellectual faculties of individuals are modified: to some are given a brilliant imagination; to others, great powers of calculation: with some, generalization is easy; with others, difficult or impossible. The senses also are quite distinct in these respects; and hence, in all ages, attempts have been made to discover in the form of the head, physical characters by which these various modifications might be detected and foretold. This led to the theory, that the brain is not exactly one organ, but an assemblage of many, to each of which was assigned its own functions, its own share in the phenomena of the intellectual and social life of man. On this doctrine was founded the celebrated *phrenological* doctrine of Gall, who endeavoured, by the inspection of the cranium, to decide on human character. Certain singular facts and coincidences appeared to favour this doctrine of the localization of the human intellectual faculties, but others equally remarkable are quite opposed to it.

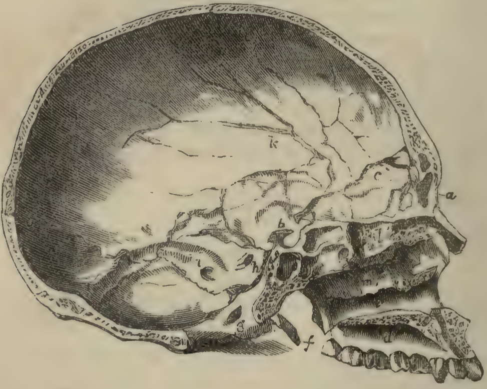

Fig. 139.—Respective Dimensions of the Cranium and Face.*

With regard to the instinctive faculties, which are so remarkable in some of the lowest animals, no relation can be discovered between these faculties and the conformation of their nervous systems, calculated in any way to explain the phenomena; nor is it possible to admit, that were such relations traced to certain structures in vertebrate animals, as the swallow, the beaver, &c. (which has not been done), the same would apply to the invertebrate kingdom, equally, if not more singularly provided with instinctive faculties, and in which the central organs of the nervous system, the brain and spinal marrow, are represented by a chain of ganglions.]

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* Vertical section of the cranium and upper jaw, left side, seen from within. Besides showing the anatomical details of these extensive and complex osseous surfaces, the section is a valuable one, physiologically: it enables the student to compare the area of the cerebral and cerebellar cavities with the area of the face, or at least of the upper jaw; the relation therefore which the encephalon has to the organs of sense. It displays also the position of the brain to the face, pharynx, and vertebral column, although these last are not present in the figure.—*d*, the osseous palate; *e*, inferior meatus of the nostrils; *m*, middle meatus; *l*, a portion of the perpendicular lamina of the ethmoid; *a*, points to the frontal sinuses; *c*, crista galli; *k*, grooves for the branches of the middle meningeal artery; *b*, posterior clinoid processes; *h*, foramen ovale; *i*, groove for the left lateral sinus; *s*, is placed near the section of the foramen magnum; *f*, styloid process of the temporal bone.—From the ***Manual of Anatomy***, by R. Knox.

[The following observations, taken from my *Manual of Human Anatomy*, will explain, though very briefly, to the student, what has been done subsequently to the time of Camper on this difficult question. I have not alluded to the memoir of my most distinguished friend Tiedemann, who endeavoured to decide the same question by filling the interior of the skull with fine sand, and comparing the results derived from the admeasurements of different races of men.—R. K.

"This is a psychological question not as yet decided. Attempts have been made in various ways to arrive at some approximation as to the mere facts, independent of all theory, but even these have not been very successful. The first proposal was the method of Camper, hence called Camper's facial angle; a mere artistic view, leading to no important results. Next followed the vertical view of Blumenbach; then the basial; lastly, the vertical, proposed by Cuvier, in which the cranium and face are

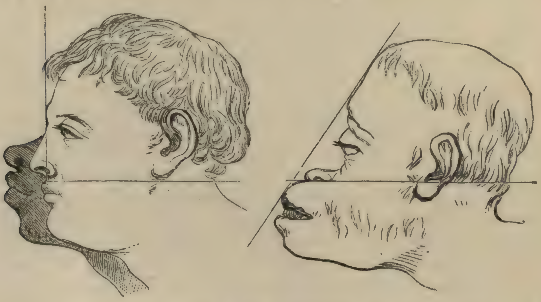

Fig. 140.—Profile of Negro, European, and Oran Outan.

divided vertically with a saw into two equal parts. Gerdy has shown that Camper's views have been wholly mistaken by nearly all subsequent writers. These are physiological questions, connected more with philosophic and transcendental anatomy than with the descriptive anatomy of adult man, the main object of this work."—From the *Manual of Human Anatomy*, by Dr. Knox. London: 1843.]

[Many later systems of cranial admeasurement have been proposed since the time of Camper. The line proposed by the Abbé Frère, drawn from the junction of the coronal and sagittal sutures to the *meatus*, is often used as the perpendicular line. Another perhaps more convenient method, adopted in this work, is the horizontal line which is drawn from the glabella to the occipital protuberance. The true axis of the skull, however, is the *longitudo racheos* of Von Baër, a line drawn through the centres of the various cranial vertebræ. Professor Huxley considers the basicranial axis to be the line drawn from the anterior margin of the *foramen magnum* to the anterior extremity of the presphenoid bone.—C. C. B.]

END OF PART I.

ON THE

CONFORMATION, CLASSIFICATION, AND GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

CONSIDERATION OF THE GENERAL PLAN FOLLOWED BY NATURE IN THE ORGANIZATION OF ANIMALS.

§ 344. THE object of the present Part is to examine the plan agreeable to which each animal is formed, and to observe how life is modified in the various classes of these beings.

§ 345. Nothing is more varied than the conformation of the various animals which people the surface of the earth; and there exists no less diversity in the various acts by which life is manifested in these animal machines. In some the functions are few, and the sphere of their physiological activity very restricted; in others the faculties are extremely varied, and their actions multiplied in the highest degree; and to express this difference in the nature of animals, it is usual to say that some are more *elevated*, more *perfect*, than others. In this way and in this view we say that a fish is more elevated in the animal scale than an oyster; a dog more than a fish; a man more so than the dog.

§ 346. *Tendency to the Localization of Functions, and to the Division of the Physiological Phenomena.*—The principle which nature seems to have adopted in the perfecting of animals, is one which has been found to exercise the most beneficial influence over human progress; it is, *the division of labour*. Thus, when we compare animals with each other, differing in the number and extent of their faculties, we shall find that the perfecting of these beings coincides with a localization more and more marked in their functions: when the same instrument serves for the production of several phenomena, the physiological result is, as it were, gross and imperfect; and an organ always performs its part better as it is more specialized. Now the mode of action of an organ or instrument, in the sense we allude to, depends always on its intimate nature, or its structure, and other qualities; and consequently, the more organs there are endowed with peculiar or specific kinds of activity, differing from each other, the more numerous will be the number of dissimilar parts in the animal economy; and the complication more or less great in the acts and faculties of animals must proceed, *pari passu*, with the natural complication of their organization.

§ 347. Thus in those animals in which the faculties are the most limited, and in which life exhibits itself in its simplest form, the body presents everywhere the same structure. There is in fact a seeming identity of organization throughout. Every part of the body performs the same functions as the neighbouring parts. If divided into segments, each part lives, and becomes an independent animal as complete as that from which it was violently separated.

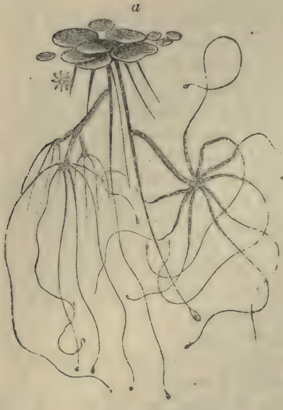

Fig. 141.—Hydra; Fresh-Water Polyp.*

The fresh-water polyp or hydra is an animal of this kind. By mutilation it is multiplied instead of being destroyed. We owe the discovery of these curious facts to Trembley, a Swiss naturalist of the last century.

The simplicity of the organization of these animals can only be demonstrated by the microscope, under which the substance of their body appears throughout identical; it is composed of a gelatinous mass, enclosing fibrils and globules extremely minute. Now identity of structure would imply identity of function, and the experiments of Trembley proved the correctness of the inference.

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* In Figure 141 several polyps are represented as attached to water-lentils, *a*; they consist of a single gelatinous tube, open at one of its extremities, and furnished with a circle of filaments called tentacula, by means of which they introduce into their bodies the food they require. One of these polyps, *b*, carries on the sides of its body two small ones which spring from it, and will soon be detached. In Fig. 4 (p. 19) may be seen one of these animals magnified still more than the above, to show its internal conformation.

§ 348. But as we ascend in the scale, we find that this simplicity of structure is confined to a very few species, and that the functions become more and more localized and specialized; and, with this specialization, more and more varied and perfect.

A first degree in this localization of physiological phenomena, is found in the earth-worm (*lumbricus terrestris*), whose body offers a series of segments of identical parts; that is, in each segment we find a portion of the alimentary canal, nervous system, and circulation; but these segments are identical, or repetitions of each other, presenting no special organ on which life in a peculiar way depends; and thus, if divided into five, ten, or twenty segments, each segment will continue to live and become an independent being.

But, for obvious reasons, this cannot be done with an animal in which the organs have become so specialized that on the integrity of some localized distinct segment, not common to all, the general vitality of the being depends.

§ 349. Already in insects we distinguish a more considerable division of labour in respect of the organs; the faculty of perceiving certain sensations and of producing voluntary motions, comes to be concentrated in certain nervous ganglions lodged in the head; this concentration of functions goes on increasing as we ascend, and embraces nearly the whole range of the animal economy, ascending through the various animals to man himself. Now it must be obvious that the destruction of one of these specialized organs, located in a single segment of the body, and all-important to life, must entail the destruction of the animal.

§ 350. *Organic Transformations and Tendency to Uniformity of Composition.*—The complication in structure as we ascend in the scale of being, takes place in some instances by the creation of organs completely new, which are thus superadded to those already existing in the lower animals; but more frequently the complication is effected in another, and, as it would seem, a much more economic way. Thus, in a great number of instances, the localization of the functions is determined by a simple modification in the disposition of parts already existing in the lower animals,—a modification by which these materials are adapted to the special purpose or use, and not to a general one. In the Molucca crab (Limulus, Fig. 142), the limbs of the cephalic and thoracic portions of the body immediately surround the mouth, and are so constructed as to form instruments of locomotion, instruments of prehension by their free extremities, and of jaws by their base; but, as might be anticipated, this very cumulation of functions renders them less appropriate for the advantageous performance of any special function. But in animals of the same class with faculties more perfect, these different functions are no longer performed by one and the same organ or instrument; each function belongs to a distinct organ, and yet these organs are still the same limbs or members, of which some are exclusively destined to mastication, others to prehension, and others to locomotion. In the craw-fish (écrevisse), or lobster, for example (Fig. 143), the limbs surrounding the mouth are exclusively arranged for mastication;

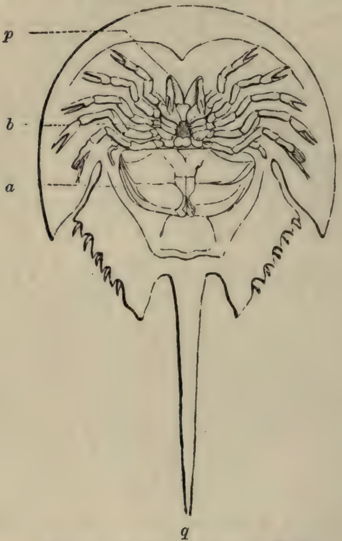

Fig. 142.—Limulus.* (Molucca Crab.)

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* The animal is represented as seen from below:—*b*, the mouth; *p*, feet whose base performs the office of jaws; *a*, abdominal appendages carrying branches; *q*, caudal stylet.

another pair, unfitted for such a function, here become the special organs of prehension; a third series of members or limbs is devoted to locomotion only, and of these, some are used only in swimming, others in walking on the firm ground.

This tendency on the part of nature to appropriate the same part of the animal economy to different functions, according to the wants of the animal, rather than to create for each species parts entirely new, reveals itself also when we compare with each other species destined to live differently. Already in the vertebrata we have seen how, out of the same elements, nature constructs a limb or arm, an instrument of prehension or one of mere locomotion and support, a fin or wing (§ 200, &c.). Such adaptations are no less curious in insects, to which we shall return; we limit ourselves here to the remark, that anatomists give the name of *analogues*, or *analogous* parts, to the organs which, however varied may be their uses in the economy, are yet obviously composed of the same anatomical elements.

§ 351. It is in general by means of such transformations that nature varies most the structure of animals. She seems to have been desirous of producing the greatest variety possible with the smallest elementary means essentially different: and to have had recourse to the creation of parts entirely new only after having exhausted the combinations to which parts already existing in other organisms could lend themselves. This disposition is connected with another tendency,—namely, the tendency to *uniformity of the organic composition*. It would be absurd to assert that all beings are formed upon one plan, and constructed out of the same materials; but if we examine the structure of one of the more complex organisms, we shall find that the lower are characterized by a modification of the larger features of the former, by an omission of some parts, or by the existence of organs of which the former have been deprived. A frog, for example, differs greatly from man, and yet in its general outline may easily be traced the indications of the plan upon which man has been constructed. When the entire animal kingdom is contemplated, it becomes impossible to perceive this unity of plan and of organization; but, by restricting the field of view, it becomes evident that, notwithstanding the immense number of animals, all have been constructed upon a few *primitive types*. Now, it is by the consideration of these primitive types that the leading divisions of the animal kingdom are established.

§ 352. *Natura non facit saltum,* was the ancient adage: its truth is exemplified by the history of the animal kingdom.

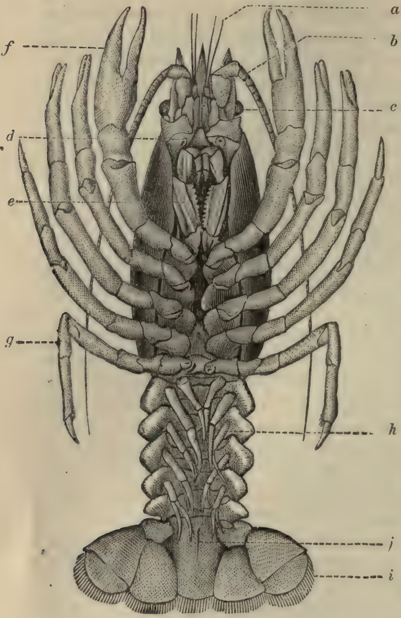

Fig. 143.—Crawfish.*

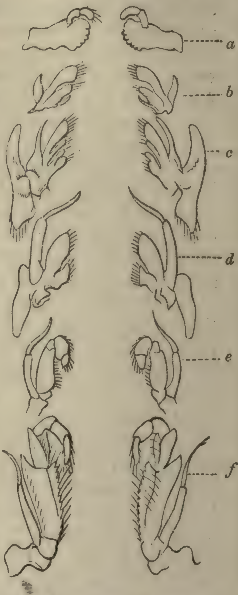

Fig. 144.—Masticatory Apparatus.

The change from one form of organization to another is never sudden, but, on the contrary, takes place gradually, and as it were by shades of difference.

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* Fig. 143. The lobster, or crawfish, seen from below :—*a*, antennæ of the first pair; *b*, antennæ of the second pair; *c*, the eyes; *d*, the auditory tubercle; *e*, mandible feet, external; *f*, thoracic feet of the first pair; *g*, thoracic feet of the fifth pair; *h*, false abdominal feet; *i*, caudal fin; *j*, anus.

Fig. 144. The six pairs of limbs which compose the masticatory apparatus of the lobster or craw-fish; *a*, mandibles; *b*, *c*, first and second pairs of jaws; *d*, *e*, *f*, the three pairs of auxiliary jaws or foot-mandibles.

It were easy to give many illustrations of this fact: two distinct plans of organization are obvious in the lizard and the carp; they differ in the general conformation of the body, their kind of life, their mode of respiration and circulation; but the salamanders, the axolotls (Fig. 145), the lepidosirens (Fig. 146), and some other animals, present us with modes of organization intermediate to these two types, and establish transitions so gradual from one to the other as to make it difficult to determine whether the animal in question be a batrachian or a fish. These transitions from one animal to another are not limited to the comparing of two distinct adult animals; they may be observed in comparing the same animal at different stages of its growth or development. Frogs, for example, present at birth nearly all the characte-

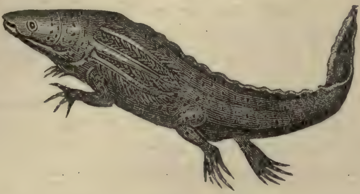

Fig. 145. The Axolotl, of Mexico. (Siren pisciforme.)

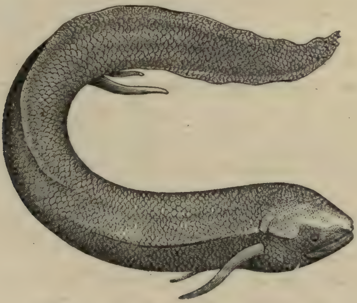

Fig. 146.—The Lepidosiren. (*Potopterus.*)

ristics of a fish, acquiring only, as they grow up, those of the reptile (Figs. 147 to 151).

Now these transitory states of the same individual present frequently a remarkable resemblance to the permanent condition of other species; and hence it results that the study of these zoological transitions conducts us not only to a knowledge of a sort of parentage or relationship between animals with forms often extremely unlike, but presents us with a philosophic interest of a higher order, for it seems to give us some ideas of the course followed by the Creator of all things in the formation of the so varied products of the animal kingdom.

§ 353. Out of this tendency to fill up all links in the animal kingdom, there arises the notion of a series or chain of animal life, each form graduating as it were into that preceding and that to follow. Sometimes, however, the link seems broken, and there is an interruption between two types, as if a part of the chain were lost or not filled in. Birds, for example, seem isolated; but, generally, the deficient link or *hiatus* may be found in the fossil remains with which the globe abounds—remains of animals, species, and genera which have now ceased to exist.

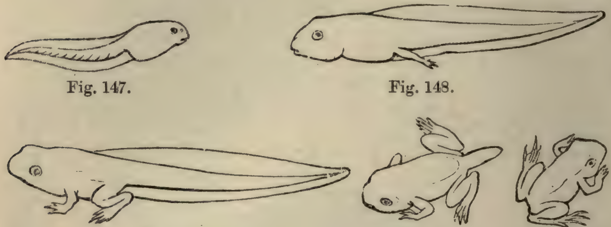

Fig. 147. Fig. 148.

Fig. 149. Fig. 150. Fig. 151.

Figs. 147 to 151.—Metamorphoses of the Frog.

Some naturalists have thought that the series or line has always been one uninterrupted series in the same direction, from the monad up to man: they have attempted to establish a zoological scale with these views; but this effort has failed, for the series of animals is not single. Animals appear rather to form a great number of series, which seem sometimes to proceed in parallel lines, sometimes to diverge and rise to different elevations. It is even impossible to arrange them in a single line according to the relative degrees of complication and of perfection introduced by nature into their structure, for these *perfections* have reference sometimes to one organ sometimes to another; and a species which, in respect of the functions of nutrition for example, might be much superior to another, may yet be greatly inferior to that species in the organs of locomotion. As we ascend, it is true, in the animal scale, from the monad to man, we remark, no doubt, a progressive complication; and it is easy to see that the mollusks are superior to the zoophytes, fishes to the mollusks, reptiles to fishes, and birds to reptiles: above all come mammals. But a closer observation shows that this gradation exists only between the animals which may be considered as the types of each of these groups; and it often happens that certain species of an inferior group possess a structure and faculties more perfect than the lowest species of a group of which the chief representatives possess an organization much more complex than that of all the former. Thus there are fishes, as certain lampreys* for example, which are in many respects much inferior to mollusks such as the sepia, but these in some measure are exceptions; and when we trace with a bold outline the grand picture of nature, it is allowable to neglect these, as we overlook or neglect to observe the lesser inequalities of the soil when we desire to perceive at once the general configuration of a chain of mountains. More serious obstacles arise to the linear arrangement of animals, from the diversity of routes followed by nature in her ascending march, and from her tendency to perfect gradually each of the types she has produced. Thus insects can neither be placed before nor after the mollusks without violating some of the most evident zoological relations; and if we really desire to express by a figure the relationship of animals, it cannot be to a scale or ladder to which the animal kingdom is to be compared, but to a river, which, weak at its source, increases little by little as it approaches the sea, rolling not all its waters in the same bed, but dividing often into branches more or less numerous, which, sometimes reuniting after a longer or shorter course, sometimes remaining from that time forward distinct, or which at other times are lost in the sands, and disappear for ever, or surging up once more, reappear at some distance, to continue their route towards the common goal.

* [*Amphioxus*, the Lancelet; *Myxine*, the Hag-fish. C. C. B.].

§ 354. *Natural Affinities and Analogies of Structure.*—This tendency of nature to observe one general plan in the construction of her works leads to another sort of relationship, which naturalists have called *natural affinities.* These affinities are always the stronger that they bear on organs of secondary physiological importance, and necessitate less change in the general plan of the organization. Thus it is obvious that the lion, cat, and tiger have strong natural affinities; between the lion and the dog there still exist natural affinities, though obviously less marked; but between the lion and the shark they are extremely feeble, excepting in so far as they both belong to the vertebrata; finally, between a fish and an oyster there are none, inasmuch as these two beings are formed on plans essentially distinct.

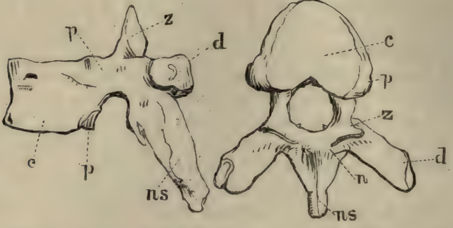

Fig. 152.—The Human Vertebra—the Type of all Skeletons. The references are explained below, Fig. 153.*

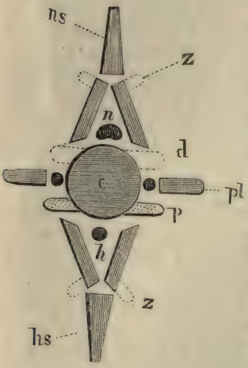

Fig. 153.—The Ideal Vertebra, as viewed by Oken, Spix, and St. Hilaire as the Type of ail Osseous Structures.†

§ 355. Between *natural affinity* and *analogy* there is this essential distinction,—*affinities* are based on the identity, more or less complete, of the type; *analogies*, on a resemblance in the details. Thus the bat (Fig. 108), a mammal, pterodactyle, a reptile, and the Dactylopterus (106), or flying-fish, have no zoological affinity, properly so called, excepting that they are vertebrate animals; but they have remarkable *analogies*, being all organized for flight, by having expansions of the integuments extended on fingers prolonged for this purpose. Indeed, in contemptlating and comparing with each other different zoological groups, it would seem as if nature's tendency was to cause each type to pass through a series of analogous modifications. Thus amongst insects, spiders, and crustacea we observe the general plan of the organization modified in the same way, according as the animal is intended to live on solid food, or as a parasite by sucking the juices of another being.

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* From the Races of Men, by R. Knox.

† [Copied from Owen.—*c*, centrum; *ns*, neural spine; *hs*, hæmal spine; *d*, diapophyses; *pl*, pleurapophyses; *n*, neurapophyses; *h*, hæmapophyses; *p*, parapophyses; *z*, zygapophyses.]

§ 356. *Organic Harmonies.*—In the midst of the innumerable variety in form and structure which the animal world presents, may be observed a certain general harmony which seems to regulate all the parts of this vast creation; and this principle of co-ordination is all the more remarkable if we restrict our observation to the entire of the structures composing a single animal. Between every part there reigns the strictest mutual dependence, so as to forbid all idea of chance in its construction; all are in the strictest accord. Some of these harmonies are so obvious and striking that the naturalist may, from the observation of a single organ—a tooth for example, deduce nearly the whole natural history of the animal. From the subjoined figure (Fig. 154) may readily be inferred that the animal had a skeleton, a cerebro-spinal axis, nerves, &c.; in short, that it was a hot-blooded mammal, and that it lived on flesh. In fact, from this single organ may be deduced nearly the whole structure of this carnivorous mammal, *à priori*, or without having ever seen it. Proceeding on these principles of organic harmonies, the true nature of the fossil organic world was first discovered by Cuvier; he it was who first applied these laws to fossils, and by these means effected the restoration of an organic world long since extinct.

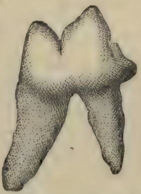

Fig. 154.—The carnassial Tooth of the Lion.

[The law of organic harmonies must be applied with the greatest caution. Cuvier seldom trusted to it; it cannot be made with safety the basis of *à priori* reasoning.—R. K. See "Trans. Roy. Soc. of Edin.," 1829.]

§ 357. In studying this law of organic harmony, we soon discover another, *the subordination of characters.* It becomes evident that all parts of the animal economy have not the same importance; that certain organs may undergo important modifications without affecting others, whilst there are others which, when modified strongly, affect the character of the rest. These may be called *dominating* organs. By these organs the anatomist, and in some measure the naturalist, must be regulated in his determinations. By the fixity or mobility of an organ he determines its importance in the economy.

§ 358. There are other principles regulating the great work of creation, on which want of space forbids us to dwell. The tendency, for example, to *repetition*, which leads to the formation of *homologous* parts;* the principle of *connexion of organs* regulating the place occupied by each; a tendency to an organic balancement, equipoise, or compensation, when the development of an organ acts as it were injuriously upon others, as if the amount of vital force were restricted and limited. All these subjects merit consideration, but space is wanting to do them justice. Sufficient has been said to show that nature proceeds always by rule and measure; and that the animal kingdom, so far from being a confused assemblage of ill-assorted beings, unfolds itself to the eyes of the observer as a vast picture, where all harmonizes and is linked together; finally, that the zoological laws are as simple as they are general.†

ZOOLOGICAL CLASSIFICATIONS.

§ 359. *Object and Nature of Zoological Classifications.*—Man naturally groups the various objects around him, and he gives to these groups a different name. This tendency to classification is one of the most remarkable of our faculties, and powerfully aids in facilitating the operations of the mind; by its means we rise from the individual to the general, and thus form generalizations and abstract ideas. It is seen in infancy, for the child gives instinctively the same name to all men that he gives to his parent, yet he does not confound the individuals; and, in a word, it may be said that this tendency to classify extends throughout the whole range of our intellectuality.

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* The term *homologue* is with some reserved exclusively for parts strictly representing each other in different animals.—R. K.

† See on this subject a work I have published, under the title of *Introduction à la Zoologie Générale*, or, Considerations on the Tendencies of Nature in the Constitution of the Animal Kingdom.

This necessity to reunite in our minds similar objects, and to give to each of the groups thus formed an ideal representative, is in fact the basis of all classification, and its necessity is in the direct ratio of the number of objects observed. An abstract type must represent every group. Thus we speak of man in general, the horse, the oak, meaning no man in particular, no horse, no oak; and to this ideal representative we give the name of *man, horse, oak.* But we do not stop here. Generalizing still higher, we represent by the word *bird* a vast group of living beings; and the terms animal or plant embrace a still higher range of generalization; and thus, from the remotest antiquity, men have divided all natural bodies into three kingdoms, namely, minerals, vegetables, and animals; have spoken in a general way of fishes, reptiles, &c.; and have given to each species a proper name.

§ 360. As science grew in its dimensions, the language of naturalists of necessity became more precise; for without a precise definition there could be no science. To write the natural history of animals, it became necessary not only to form a great catalogue, in which each being should be designated by its proper name, but also to indicate for each of them the characters by which they could be recognised and distinguished from all others. Now it was evident that, from the conformation alone of these beings could such characters be drawn, those alone being constant. But there is no animal which can be recognised by a single character, but by a reunion of several—a reunion not to be found in any other. But the number of animals being immense, the definition soon degenerated into a description of the animals, to which no memory was equal; and if we possess not the means of arriving at this end by an easier route, the study of natural history would for ever remain in its infancy. By establishing among animals divisions and successive subdivisions, which themselves are named and characterized, a great part of this difficulty is overcome. With the assistance of a small number of characters and names, we so circumscribe the field of comparison, that to distinguish the object before us we have only to observe its differences from those most allied to it.

And this, in fact, is what naturalists have done. They have divided the animal kingdom into a certain number of groups of the first degree, each characterized by certain peculiarities of structure. They next divide each of these groups, and characterize the secondary groups thus formed in the same manner. These secondary groups are in their turn divided, and the sections multiplied as required, until at last nothing is left in the same group but the different individuals of the same species.

Classification, then, is a sort of *catalogue raisonné*, in which all beings are arranged according to a certain order, and reunited into groups, recognisable by determinate characters, which in their turn are reunited into other groups of a still more elevated place.

§ 361. The practical utility of such classifications is easily seen by comparing it with the address of a letter. So it is with the naturalist, who, by his zoological classifications, arrives speedily to the groups to which the animal belongs. If, for example, he was desirous to define a *hare*, without resorting to such means he would be forced to compare his description to that of more than one hundred thousand different animals. But if he says that the hare is a *Vertebrate* animal of the class *Mammalia*, of the order *Rodentia*, of the genus *Lepus*,—by the first he excludes all invertebrates from his comparison; by the second, he excludes all reptiles, fishes, and birds; by the third, he distinguishes the hare from nine-tenths of these mammals; and having thus arrived at the genus to which it belongs, a very few distinguishing characters in addition will enable him to characterize the species for certainty.

§ 362. *Artificial and Natural Classifications.*—Zoological classifications are of two kinds, *artificial* and *natural.*

In the artificial classification of animals, the divisions are based on modifications which certain parts of the bodies present, and which are chosen arbitrarily; in the natural classification, on the contrary, the whole of the organization of each being is taken into consideration, and then arranged accordingly.

§ 363. An artificial system is generally of easy application, but it often gives us no important information but the name of the object. Suppose we take the number of the limbs as a base for classification, we should place in the division quadrupeds the ox, the frog, the lizard, &c., thus violently separating animals from their natural affinities, and grouping together those which have none.

§ 364. *By the natural method*, the divisions and subdivisions of the animal kingdom are founded on the whole of the characters furnished by each animal, arranged according to their degree of respective importance; thus, in knowing the place which the animal occupies, we also know the remarkable traits of its organization, and the manner in which its principal functions are exercised.

§ 365. The rules to be observed in arriving at a natural classification of the animal kingdom are of extreme simplicity, but often there is much difficulty in the application. They may be reduced to two, for the object of the zoologist in establishing such a classification is,—

1st. To arrange animals into natural series, according to the degree of respective affinities,—that is to say, to distribute them in such a manner that the distance from, or proximity to, a species, is the measure of the resemblance or dissemblance.

2nd. To divide and subdivide this series according to the principle of subordination of characters,—that is to say, by reason of the importance of the differences which these animals present between them.

§ 366. To be satisfied, for example, of the affinity which exists between the cat and the tiger, it is not necessary to study the anatomy of these animals, for the external forms translate, as it were, the character of the internal. But in a great number of instances the examination of the internal structure becomes necessary, in order to avoid important errors. Thus, for a long time, the relations which exist between the lernææ, parasitical animals with strange forms (Fig. 155), which live on fishes, and the smaller crustacea of fresh waters, known to zoologists by the name of cyclopes (Fig. 157), were not understood; because in their adult state these two animals do not resemble each other,—but since naturalists have studied their development they have become convinced of their relationship, for when young they differ so little from each other that it would be often difficult to distinguish them (Figs. 156 and 158). Finally, to fulfil the first of the two conditions pointed out above, it becomes necessary to overcome other difficulties depending on the multiplicity of the relations of each animal with those surrounding it, and of the diversity of the transitions by which nature passes from one type to another. By reason of these circumstances, it is also impossible to arrange animals in a single linear series, without violating at every instant their respective affinities, and we are obliged to disperse them into several parallel lines, or lines branching out from each other.

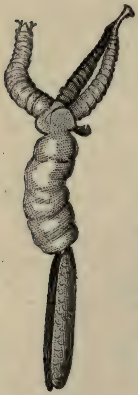

Fig. 155.—Lernæa.

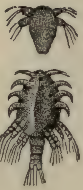

Fig. 156.—
Larvæ of
the Lernæa.

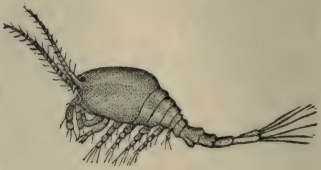

Fig. 157.—Cyclops, one of the
Entomostraca.

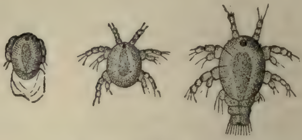

Fig. 158.—Larvæ of the Cyclops.

[Such relations being based on embryology, which again rests on the transcendental, must be used with great caution, and must not be mistaken for any natural generic or specific *consanguinité* between the animals forming the subject of observation. The young of the *Balanus*, or acorn-shell, whilst in the larva state, also closely resembles the *Entomostraca* (microscopic shell-fish) as well as that of the *Lernææ*. In a philosophic sense, however, such observations are, notwithstanding, exceedingly interesting; and they tend to show that animals which we have hitherto considered as adult, specific, and fully developed, may after all be merely "arrested forms" of others passing through various metamorphoses.—R. K.]

§ 367. The second condition in the establishment of a natural classification is an exact relation between the successive divisions of the animal kingdom and the importance of the modification of structure serving as the basis to these sections.

The characters which distinguish animals from each other are far from having the same value: some are of seemingly little or no physiological importance, seeing that their variations do not draw after them differences in the rest of their economy; others never vary without coinciding with profound modifications in the whole of their organization; hence they are called dominating, since they seem in some measure to regulate these modifications. It is evident, then, that divisions of an inferior rank can alone be based on subordinate characters, while those of a higher rank ought to be founded on those called dominating. To arrive, then, at a natural classification of animals, it is above all necessary to know the structure, functions, and mode of development of these beings; next, to inquire into the dominating characters of the organization of each. This we arrive at sometimes by physiological considerations, at other times by anatomy only. Fixity is an index of an organic domination, whilst the characters which vary from one small group to another, are generally but of little interest. The nature and the degree of development of the faculties, of which the organ thus modified is the instrument, enables us also to judge, to a certain point, of the zoological value of a modification of structure. But in other cases, the determination of dominating characters presents considerable difficulties, and analogy is not always a safe guide, for the importance of an organ may vary considerably in passing from one animal to another, and a part which dominates in some sort the whole economy in some species may in others be found fallen from its rank, and reduced to play a secondary part.

§ 368. Zoologists are far from knowing the anatomy and physiology of all animals; neither are they agreed on the relative importance of a great number of modifications of structure which animals present. It is evident, then, that in the existing state of science there can be no natural classification; hence also the variety of methods adopted by different authors, and the modifications these methods daily undergo. But this mode of classification must of necessity become more perfect as our knowledge extends, and its instability, far from being a defect, is the necessary consequence of its perfectibility.

§ 369. The introduction of natural methods of classification of living beings is one of the greatest services rendered to natural history; it has changed the aspect of the science, and given a powerful interest to that part of botany and zoology which heretofore was the most arid.

The distinguished men to whom we owe this innovation began with plants, which before their time were arranged arbitrarily by the number of their stamens and pistils, or after some other character chosen without regard to their analogies. Towards the middle of the last age, a French botanist, Bernard de Jussieu, conceived the happy idea of distributing them in groups according to the whole of their organization; and his nephew, Antoine-Laurent de Jussieu, applied this idea to the entire of the vegetable kingdom, and assuming as a basis of his classification the consideration of the dominating characters (*see* § 357), created the natural method at present adopted by all naturalists.

§ 370. *Mode of Division of the Animal Kingdom.*—The animal kingdom is composed only of individuals; but among these there is a certain number which have an extreme resemblance to each other, and which are reproduced with the same essential characters; these reunions of individuals formed after the same type, constitute what naturalists call *species*. Thus man, dogs, horses, form for the zoologist so many distinct species.

Sometimes the species differs considerably from all others; but in general there exists a number more or less considerable which strongly resemble each other, and which are only distinguished by differences of little importance; such as the horse and the ass, the dog and the wolf. For natural classifications, these closely allied species are reunited into groups called *genera*, and to their specific name a generic name is also added, common to them all; thus we say the grey, the spotted, the ocellated lizard, &c., to designate different species of the genus lizard; and brown bear, white bear, &c., for the different animals of the genus bear. Genera which resemble each other are grouped together by the name of *tribe, or natural family.*

If we afterwards consider the structure of animals in a more general way, we cannot fail to recognise in several families the same dominating characters, thus giving to them in spite of their differences, a certain common character. In this way the naturalist forms divisions of a more elevated rank, which he calls *orders*, and reunites in turn these orders into groups still more numerous, called classes. But the classes themselves admit of being divided by the same principles into *embranchements*, or primary divisions of the animal kingdom.

§ 371. Thus the animal kingdom is divided into primary divisions, these divisions into classes, the classes into orders, the orders into families, the families into genera, and the genera into species; sometimes we are even obliged to multiply these sections, but the principles are always the same: the differences which exist between two classes ought to be more important than those existing between two families, as the characters of families ought to have a greater value than the characters of the genera out of which these families are composed. Thus it is the more important differences which serve for the establishment of the primary division, those of less importance which constitute the basis for the subdivision of these into classes, and so on, until we arrive at species or groups, formed, as we have already said, by the assemblage of all the individuals closely resembling each other, and which may unite to perpetuate their race.

It is evident then, in order to class any animal in the primary division, the class, order, family, genus, and species to which it belongs must first be determined, and that by this determination alone we obtain precise ideas respecting all which its organization offers of most importance, since it is in fact these very peculiarities which serve to characterize these successive divisions. Now, we repeat, the functions and manners of an animal are always dependent on the mode of conformation of its organs, or at least in harmony with its structure, and that consequently we may deduce from this knowledge all the most important points in the history of the species submitted to our investigations.

Such are the bases on which rest the zoological classifications called natural. Let us now see what have been the results of the application of these principles to the methodical distribution of animals, and let us study the principal groups formed by these beings.

BASES OF THE DIVISION OF THE ANIMAL KINGDOM INTO PRIMARY DIVISIONS (SUB-KINGDOMS) AND CLASSES.

§ 372. *Primary Divisions.*—Four general plans of structure, modified in a thousand ways, seem to have served as guides for the creation of the animal kingdom. These four principal forms may be understood by a reference to four

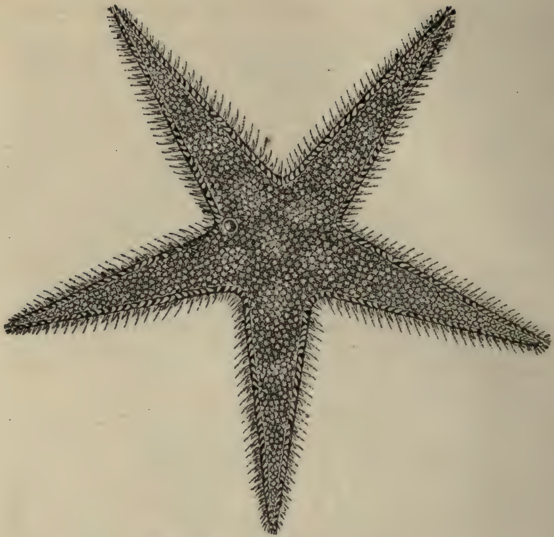

Fig. 159.—Asterias, or Sea Star.

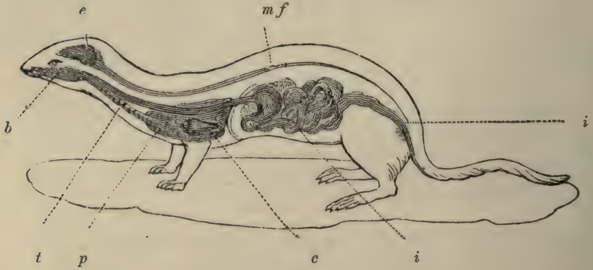

Fig. 160.*

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* This theoretical figure is intended to indicate the relative position of the great organic apparatuses in the class mammals:—*b*, buccal cavity forming the entrance of the alimentary tube,—the exit is at the posterior extremity of the body; *i*, the intestine; *f*, the liver; *t*, trachea; *p*, lungs; *c*, the heart; *e*, encephalon (brain, &c.); *m*, spinal marrow.

well-known animals—the dog, the crawfish or lobster, the snail, the asterias or sea-star (Fig. 159.)

In order that the zoological classification be a faithful representation of the more or less important modifications introduced into the structure of animals, it was necessary to distribute these beings into four principal groups or divisions and this is, in fact, what Cuvier did.

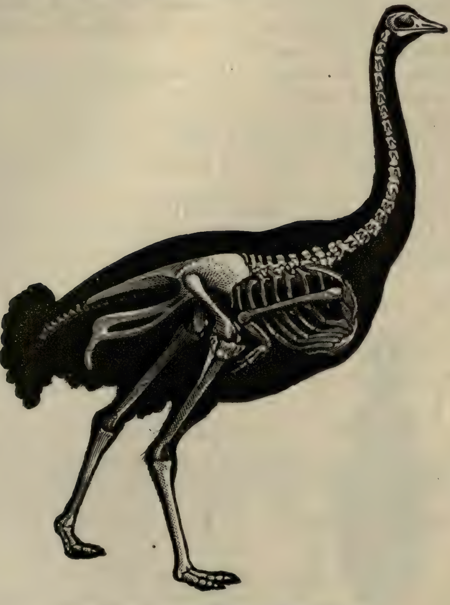

Fig. 161.—Skeleton of the African Ostrich.

The animal kingdom is divided into *vertebrate animals*, *articulated* or *annulated animals*, *molluscs*, and *zoophytes*.

§ 373. The fundamental differences distinguishing these four primary divisions depend chiefly on the mode of arrangement of the different parts of the body and on the conformation of the nervous system. It is easy to understand the importance of these two dominant characters: to feel and to move is the especial character of animal life, and these two functions belong to the nervous system. It might readily, then, be anticipated that the mode of conformation of this system would exert a powerful influence over the nature of animals, and would furnish characters of primary importance in classification.

The general disposition or mode of reunion of the different parts of the body exercises an equally important influence, as modifying the localization of the functions and the division of the physiological result.

Although it is easy for the zoologist to distinguish the four groups just mentioned, and to refer to one or the other of them an animal under examination, yet there are some beings which seem connected with two different types, like border lands whose rights of possession have not yet been determined.

It sometimes also happens that it is difficult to define rigorously these four groups; but, to give an exact idea, it will be sufficient to indicate the more prominent characters peculiar to each type, and to remark, that the reunion of all these characters is not always to be met with, sometimes one and sometimes another being effaced as we descend to the limits of the division.

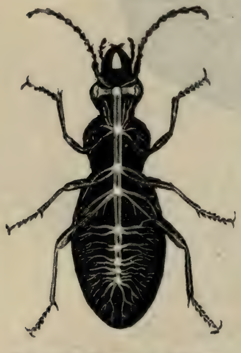
Fig. 162.—Nervous System of an Insect (*Carabus*, a Beetle).

§ 374. The *vertebrate animals* resemble man in the more important points of their structure; almost all the parts of their bodies are in pairs, and disposed symmetrically on the two sides of a median longitudinal plane; their nervous system is highly developed, and is composed of nerves and ganglions, and of a brain and spinal marrow. To these we may add, that the principal muscles are attached to an internal skeleton (Fig. 161), composed of separate pieces, connected together, and disposed so as to protect the more important organs, and to form the passive instruments of locomotion; that the more important part of this skeleton forms a sheath for the brain and spinal marrow, and results from the reunion of annular portions, called vertebræ; that the apparatus for the circulation is very complete, and that the heart offers at least two distinct reservoirs; that the blood is red; that the limbs are almost always four in number, and never more; finally, that there exist distinct organs lodged in the head for sight, hearing, smell, and taste. We have instanced man and the dog as specimens of this type, but we may also include the bird, the reptile, and the fish.

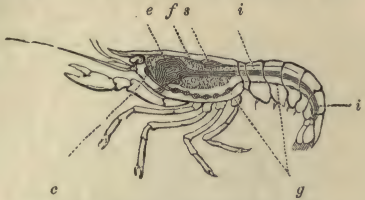

Fig. 163.—Ideal Section of the body of a Lobster or Crawfish.[*]

§ 375. *Annulated Animals, or Entomozoaria.*—In the second primary division of the animal kingdom we find a general mode of conformation quite different from the preceding. The body is still symmetrical and binary, as in the vertebrate animals, but it is composed of a series of parts which repeat each other, so that it may be divided into a considerable number of segments, homologous [or at least analogous, R. K.], and more or less like each other (Fig. 164). The nervous system is moderately developed, and is composed of a double series of small medullary centres, called ganglions, reunited in a longitudinal chain, so as to occupy the greater part of the length of the body (Fig. 162).

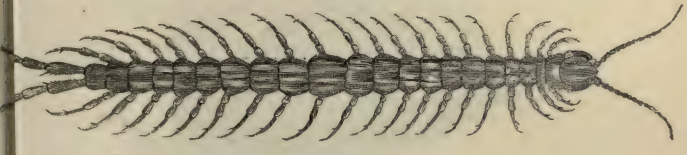

Fig. 164.—Centipede Scolopendra.

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[*] Ideal section of the body of a lobster or crawfish :—*e*, the stomach, underneath which may be seen the gullet and the mouth ; *i*, intestine ; *f*, the liver ; *s*, the heart ; *c*, cephalic nervous ganglions situated before and above the gullet ; *g*, thoracic and abdominal ganglions situated below the alimentary canal.

The small mass formed by the first ganglions of this connected chain is lodged in the head, and for this reason has been compared to the brain of the vertebrata; but we find nothing resembling the spinal marrow, for the rest of the chain of ganglions is situated on the ventral surface of the body under the digestive tube (Fig. 163), and the nervous cords uniting them to the ganglions of the head surround the gullet like a collar. All the muscles are attached to the skin, and there is no internal skeleton; but the integuments, by their hardness, form a sort of external skeleton, being arranged in rings more or less moveable on each other. Thus, the annulated or articulated character of these animals may be seen externally; the limbs, in general, are very numerous; the organs of the senses less numerous and less perfect than in the vertebrata; the blood is almost always white, and the circulation very incomplete: finally a number

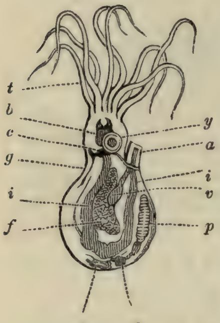

Fig. 165.—Section of a Cuttlefish.*

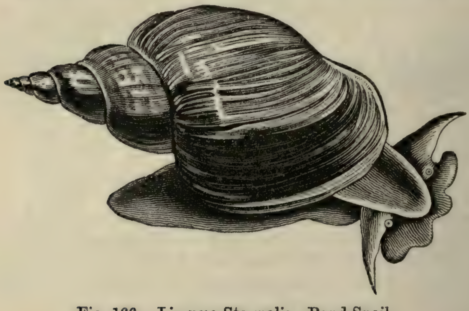

Fig. 166.—Limnæa Stagnalis; Pond Snail.

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* Ideal section of the body of a cephalopodous mollusc (a Cuttlefish):—*t*, arms or tentacula surrounding the head; *b*, the mouth; *i*, the alimentary canal; *a*, the anus; *f*, the liver; *c* and *g*, nervous ganglions; *p*, branchiæ; *s*, the heart; *v*, ink-bag or vesicle; *y*, the eyes.

of other peculiarities are found in the structure of these animals, to which we shall afterwards return;—the scolopendra or centipede (Fig. 164), the lobster or crawfish, crabs, insects, &c., are specimens of this primary division of the animal kingdom.

§ 376. *Molluscous Animals.*—The molluscs have, like the preceding, the principal organs in pairs, and symmetrical; but the body has a tendency to assume a spiral or curved form, so that the mouth and anus, instead of occupying the two extremities of the trunk of the animal, are more or less contiguous. The nervous system is composed essentially of ganglions, as in the annulata; and here also a portion of this system occupies the dorsal aspect, and another portion the ventral aspect, of the digestive tube; but these ganglions do not form a long median chain, as in the preceding division.

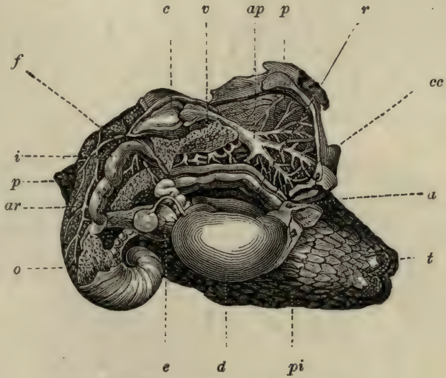

Fig. 167.—Anatomy of the Snail.*

They have no skeleton internally or externally; their body is soft, and their skin constitutes a flexible and contractile envelope or mantle; it is often covered with horny or calcareous plates, called shells (Fig. 166), and this is sometimes developed in its interior. In this primary division the organs of the senses are almost always very incomplete; there seems to be no special organism for smell, and in a great number the eyes are wanting: they have hardly ever limbs for locomotion; and finally, the blood is white as in most of the annelides, but the circulation is often much more complete.

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* *pi*, the foot; *t*, tentacle, half contracted; *d*, a sort of diaphragm separating the respiratory cavity from the other viscera; *e*, portion of the stomach; *f*, the liver; *o*, the ovary; *i*, intestines; *r*, rectum; *a*, anus; *c*, the heart,—the pericardium has been opened; *ap*, pulmonary artery, ramifying on the walls of the pulmonary cavity *p*; *ar*, aorta; *v*, gland secreting the viscosity; *c e*, its excretory canal opening near the anus.

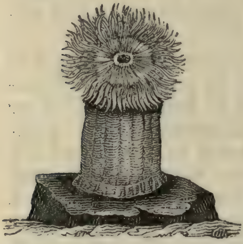

Fig. 168.—Actinia; Sea-Anemone.

§ 377. *Zoophytes.*—Finally, in the fourth and last primary division, the different parts of the body, in place of being grouped symmetrically with reference to a median plane, tend rather to arrange themselves around a central point or vertical line, so as to affect a radiated disposition more or less complete. With regard to a nervous system, no trace is generally to be observed, and where it exists, it is reduced to a rudimentary state; the organs of the senses are also almost completely wanting; finally, all the parts of the economy become of an extreme simplicity. For a long time they were mistaken for vegetables, and hence their name of zoophyte or animal-plants, and they have been called radiated animals, by reason of the obvious radiated disposition of their organs. The polyps, of which we have already spoken (§ 347), the actiniæ or sea-anemones (Fig. 168), and the asterias or sea-star (Fig. 159), are specimens of this division.*

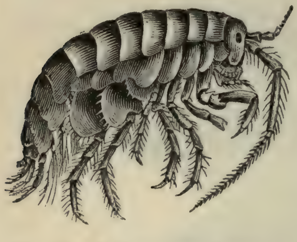

Fig. 169.—Talitrus; Sand-hopper.

§ 378. *Subdivisions of the Primary Division into Classes.*—The animals thus arranged under a primary division resemble each other sufficiently to admit of that arrangement, but they differ in many important circumstances, and hence their subdivision into classes.

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* Some zoologists admit a fifth primary division of the animal kingdom, comprising sponges, and characterized by the absence of all regular form. But it seems to us that this classification ought not to be adopted, for these

§ 379. Thus, amongst vertebrate animals, some are born alive, and are provided with mammæ for the nourishment of their young; others spring from an egg, in which they find all the nutriment necessary for their constitution, and hence are without organs of lactation; some respire in the air, others in the water; in some the circulation is complete, in others incomplete; some have the blood hot, in others it is called cold, comparatively: finally, some are formed to rise into the air, others to live on the ground, and others to swim in the depths of the waters. The differences are of a high physiological importance, and coincide, so as to characterize in this division five secondary types; and hence, to class

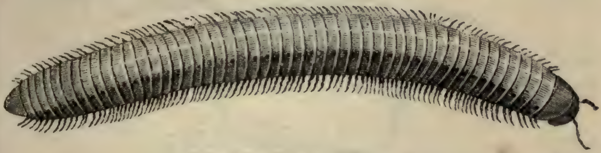

Fig. 170.—Iulus; Millipede.

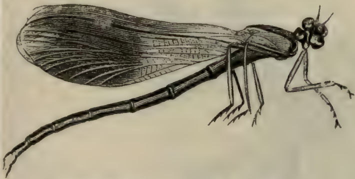

Fig. 171.—Agrion; Dragonfly.

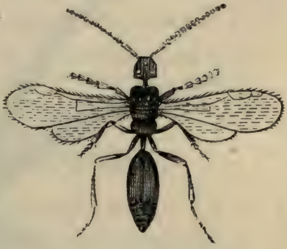

Fig. 172.—Béthylus.

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strange animals (*amorphozoaria*) present when young the same characters as polyps, only their organic development is arrested at a transitory state, and they become deformed as they grow older. Thus by keeping in view their mode of development, they may be referred to the class zoophytes.

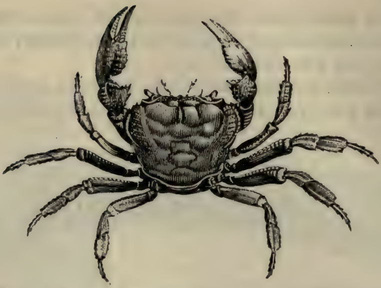

Fig. 173.—Thelphusa. A Land-crab; but some live in fresh water.

vertebrate animals according to the principles of the natural method, they must be divided into five classes

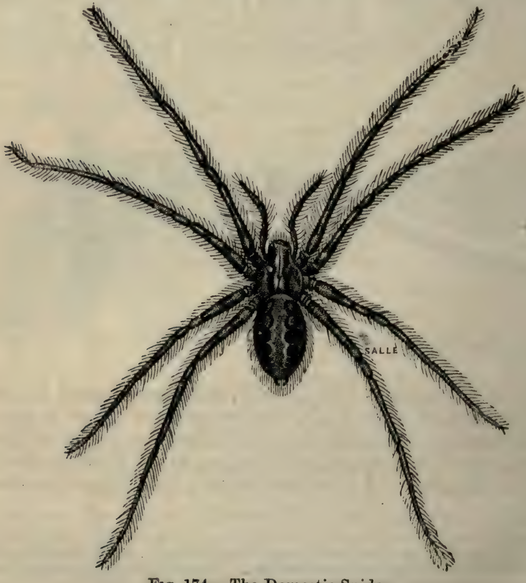

Fig. 174.—The Domestic Spider.

—namely, *mammals*, *birds*, *reptiles*, *batrachia*, and *fishes*.*

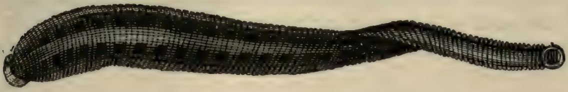

Fig. 175.—The Leech.

§ 380. In the primary division of the entomozoaria, or annulated animals, we observe modifications of structure no less remarkable. Sometimes, as in the talitrus, there exist articulated limbs serving as levers in the apparatus of locomotion; and the cephalic portion of the ganglionary nervous system acquires considerable importance. Sometimes, on the

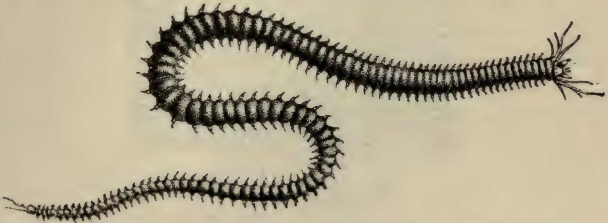

Fig. 176.—Nereis; called by the Dover fishermen "the Mud-worm."

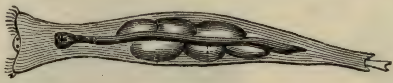

Fig. 177.—Rotifera; Wheel-bearing animals.

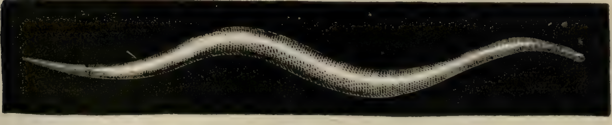

Fig. 178.—Ascaris; an intestinal worm.

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* In the early editions of this work, the vertebrata were divided into four classes, following Cuvier's arrangement; the batrachia for good reasons have since been separated from the reptilia.

contrary, as in the leech, there are no articulated limbs, the nervous ganglions are but little developed, and present a remarkable uniformity in structure and functions. We may thus subdivide this primary division into two secondary groups—namely, the articulated animals, properly so called,

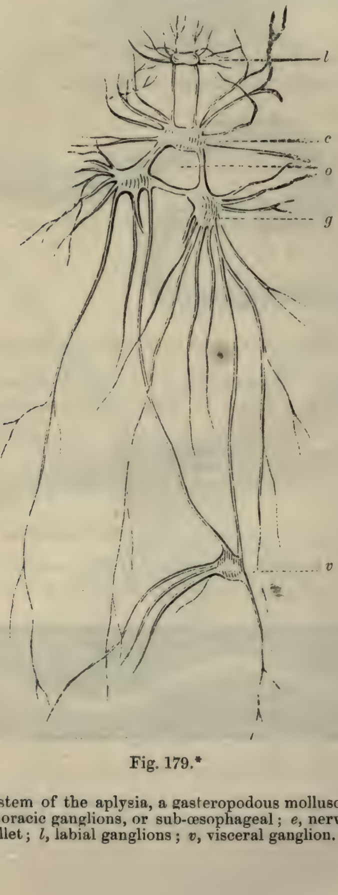

Fig. 179.*

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* Nervous system of the aplysia, a gasteropodous mollusc :—*c*, cerebroid ganglions ; *g*, thoracic ganglions, or sub-œsophageal ; *e*, nervous collar surrounding the gullet ; *l*, labial ganglions ; *v*, visceral ganglion.

and the *vermes* or worms; but this classification is not sufficient to represent all the great differences in the nature of these beings.

In fact, amongst the articulated animals, properly so called, we find insects (Figs. 171 and 172) which receive the air into all parts of the economy by means of tracheæ, which have the body subdivided into three dissimilar parts—the head, the thorax, and the abdomen, which have always three pairs of feet, and which are almost always provided with wings: the myriapoda (Fig. 170), which resemble insects by their mode of respiration, and which have also a distinct head, but have

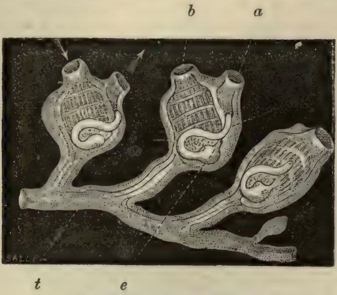

Fig. 180.—Social Ascidiæ.*

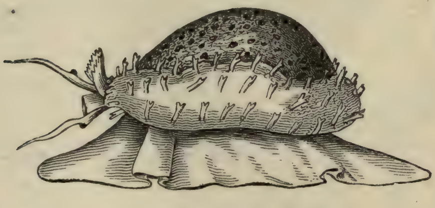

Fig. 181.—Cypræa; Cowry.

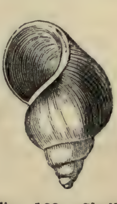

Fig. 182.—Shell of the Paludina; Marsh Snail.

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* Ascidiæ of the genus *Porophora*:—*b*, mouth; *e*, stomach; *i*, intestine; *a*, anus; *t*, common stalk. The arrows indicate the direction of the current of water serving for respiration.

not the trunk divided into thorax and abdomen; which have from twenty-four to sixty pairs of feet, and even more, but which never have wings: the spiders (Fig. 174), which have not the head distinct from the thorax, which have always only four pairs of limbs or feet, and which respire the air like all the preceding, but which have no tracheæ, and receive the fluid into pulmonary pouches: the crustacea (Fig. 173), which

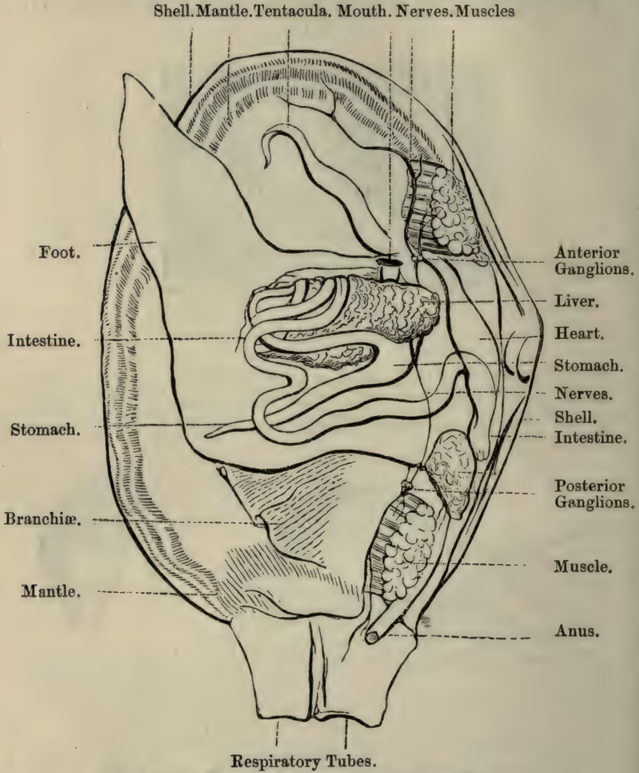
Shell. Mantle. Tentacula. Mouth. Nerves. Muscles
Foot.
Intestine.
Stomach.
Branchiæ.
Mantle.
Anterior Ganglions.
Liver.
Heart.
Stomach.
Nerves.
Shell.
Intestine.
Posterior Ganglions.
Muscle.
Anus.
Respiratory Tubes.

Fig. 183.—Anatomy of an Acephalous Mollusc (Mactra).

have, on the contrary, an aquatic and branchial respiration, and which have always from five to seven pairs of limbs adapted for locomotion.*

The division of *vermes* or worms ought to comprise also several very distinct types. There is first the annelides (Fig. 175), whose ganglionary system is quite distinct throughout its whole length, with red blood generally circulating in a very complex vascular system, in which the respiration almost always takes place in a well-developed branchial apparatus, and in which the movements are performed in general by means of moveable bristles (Fig. 176); with these also we arrange the rotifera, microscopic animals, which seem to have no special organs for the circulation, and which have no branchiæ, but which have in general vibratile organs very singular in their arrangement (Fig. 177). Finally, it is also to this primary division that we must refer the turbellaria, whose body is without limbs, and whose nervous system is composed essentially of two lateral cords springing from two cephalic ganglions. The intestinal worms, or helminthiæ, belong also to this division; their structure is very simple; they present only vestiges of a nervous system, and yet are intimately allied to the annelides, which often seem to be in some measure the degraded representatives of the same zoological type.†

To place the classification of annulated animals in harmony with the differences which we have pointed out in the nature of these beings, they must be divided into eight distinct classes, the names of which we have already pointed out in the preceding considerations.

§ 381. The primary division of the molluscous animals presents organic modifications necessitating a similar subdivision. In the molluscs, properly so called, there is a nervous system, composed of two or more pairs of nervous ganglions, reunited by medullary cords (Fig. 179); and reproduction is accomplished only by means of eggs. In others, which I shall call *molluscoïdes*, the nervous system, reduced to a rudimentary state, seems to consist of only a single ganglion, and in most cases the multiplication of individuals takes place by the development of granulations (*bourgeons*) as well as by oviparous generation; it happens therefore frequently that individuals springing from each other remain united together, constituting animated masses, phytoid, in fact (Fig. 180).

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* It has been known for some years that the cirrhipedes, which had been formed into a particular class, ought to be restored to the class crustacea.

† Naturalists are not agreed in respect of the classification of the entozoa, or intestinal worms. Cuvier arranged them amongst the radiata or zoophytes; but they more resemble the annelides in the conformation of their bodies.

The molluscoïdes are subdivided into two classes, according as they have the respiratory apparatus enclosed in the mouth, or formed by a corona or circle of long labial tentacula. The first are called *tunicata* (Fig. 180); the second forms the class *bryozoa* or *polyzoa.*

The mollusca, properly so called, differ amongst themselves by characters whose importance is still very considerable. Thus, in some the cephalic ganglions are very distant from the abdominal; there is no distinct head, nor trace of the special organs of the senses; the organs of movement are extremely imperfect, and the body is wrapped up by cutaneous folds, protected exteriorly by a bivalve shell (Fig. 183). Muscles, oysters, &c., present this mode of organization. Other mollusca, as the snail, limnæus (Fig. 166), and the cowry (Fig. 181), have a distinct head: their nervous ganglions are generally close to each other, and grouped around the gullet; they have eyes; the lower surface of the body is occupied by a fleshy organ, serving for locomotion; finally, the back is generally protected by a shell, and this is never bivalve, but represents almost always a cone turned into a spiral (Fig. 182); others have a distinct head like the preceding, and on each side of the neck a kind of membranous wing, which serves as an oar (Fig. 184).

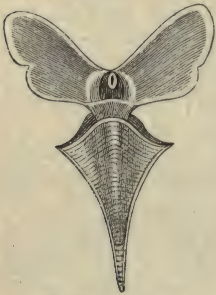
Fig. 184.—Hyalæa.

Finally, there are some which have the head furnished with long contractile and prehensile appendages, performing the functions of feet and arms (Fig. 185).

These have the nervous system more developed than in other animals of the same primary division, and which generally have the body supported by a sort of interior shell. Such are the various modes of conformation serving as a basis of the division of the mollusca, properly so called, into four classes, called *acephala*, *gasteropoda*, *pteropoda*, and *cephalopoda.* The oyster may represent the type of the first, that is, of the acephala; the snail that of the gasteropoda; the hyalæa (Fig. 184) that of the pteropoda; and the sepia (Fig. 185) the group of the cephalopoda.

§ 382. Finally, the fourth and last primary division of the animal kingdom, the zoophytes, comprises also very varied animals, and is divided into several classes. In one of these groups, called the class echinodermata, the body is formed to creep on the sand or rocks at the bottom of the sea, and for this purpose the surface is provided with a number of small prehensile appendages; the integuments also are of considerable consistence, and even sometimes of a stony hardness.

The sea-stars, the holothuria, sea-cucumber (Fig. 186), and the sea-urchins, are types of this class.

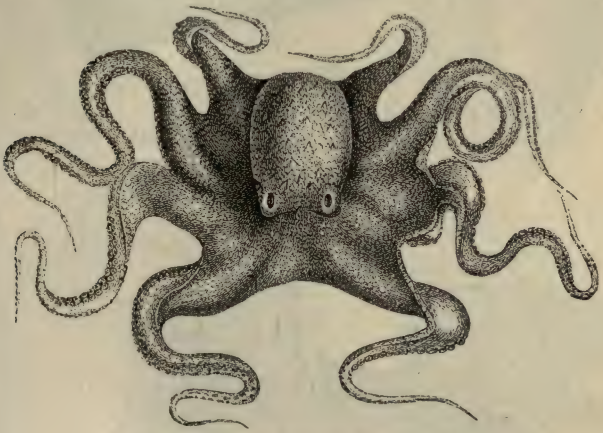

Fig. 185.—The Common Sepia, or Cuttlefish.

In the second group, formed by the acalepha, the body is, on the contrary, entirely gelatinous, and formed only for swimming. The medusæ (Fig. 188), which float in the sea and are frequently stranded on the sandy shores of the coast, are examples of this class of zoophytes.

In a third class, that of corallines or polyps, properly so called (Fig. 187), there exists no longer any organ of locomotion: the destiny of the animal is to live fixed to the soil, and its mouth is surrounded with moveable tubercles (Fig. 189), by means of which it gathers in the surrounding waters the corpuscles necessary to its nutrition; in general, a portion of the integuments becomes ossified, so as to form for it a kind of calcareous or horny dwelling (Fig. 190); and in most cases also the young spring from granulations arising on the surface

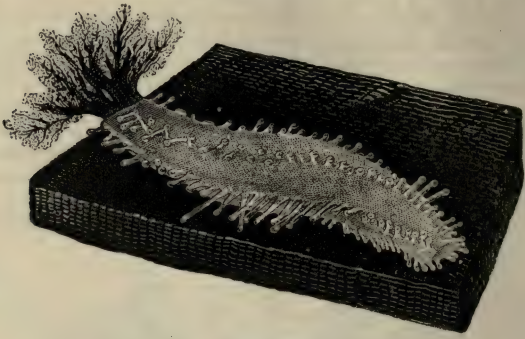

Fig. 186.—Holothuria; Sea Cucumber.

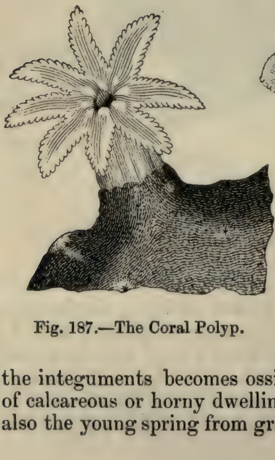

Fig. 187.—The Coral Polyp.

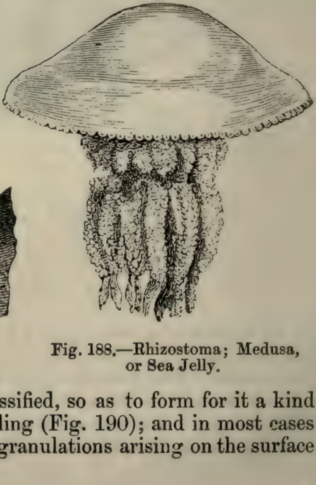

Fig. 188.—Rhizostoma; Medusa, or Sea Jelly.

of the bodies of their parents, and as they do not become detached, constitute animated masses of varied forms, resembling a branching plant loaded with flowers.

The actiniæ or sea-anemones (Fig. 168) belong to this class; so also does the coral polyp (Figs. 187, 189), the caryophyllia (Fig. 190), &c.

Sponges (spongiariæ) offer a fourth type; these are singular animals, which, when young, have an ovoid form, swim freely by means of the vibratile cilia with which their bodies are provided, and resemble at this stage of their growth the larvæ of the acalephæ and of the polyps: but they soon become fixed (Fig. 191), and then lose not only their sensibility and power of motion, but become so degraded as to resemble nothing in the animal kingdom.

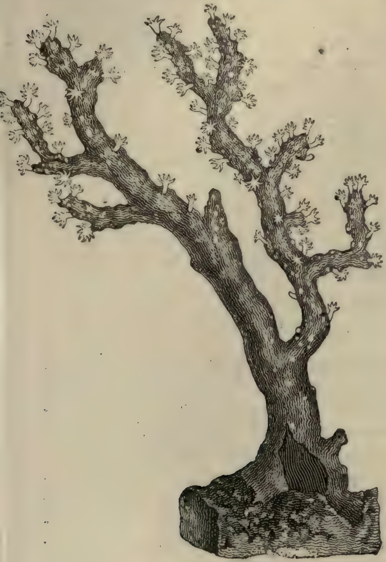

Fig. 189.—Stalk of the Coral.

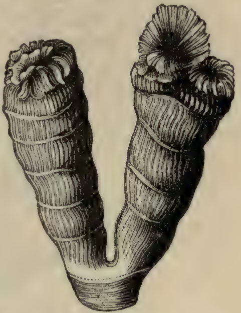

Fig. 190.—Polyp of the Genus Caryophyllia. A Coral Polyp.

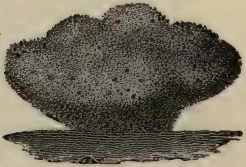

Fig. 191.—The Sponge.

Finally, most naturalists also arrange in the division zoophytes a fifth group, composed of an infinite number of beings, extremely small (Fig. 192), which live in stagnant waters, and are called *infusorial animalculæ.* They move by means of their vibratile cilia, and strongly resemble in general the larvæ of sponges (spongiariæ), of polyps, and of the acalepha; but they do not change as they grow up, and they are remarkable for their fissiparous reproduction, and for the considerable number of stomachs hollowed out in the interior of their bodies for the reception of food. These beings until very lately were confounded with the systolides, under the common name of *microscopic animalcules* or *infusoria,* and in order to distinguish them they were often called *polygastric infusoria.* The place they ought to occupy in our zoological classifications has not as yet been well determined.

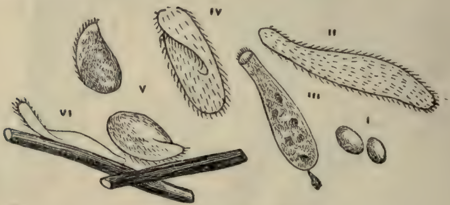

Fig. 192.—Infusoria.*

Such are the more prominent characters of the principal organic types of the animal kingdom. The sketch just given will suffice to give the reader a general idea of the modifications introduced by nature into the structure of animated beings; but to limit our view to this would lead to extremely imperfect ideas of the true nature of zoology. It becomes necessary, therefore, to examine more carefully each of the great divisions corresponding to these fundamental differences. The subjoined tabular view, representing a synoptic table, will assist the reader in comprising at a glance the basis of the classification adopted in this work.

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* Various polygastric infusoria, seen under the microscope :—I, monads; II, trachelia anas; III, enchelis, represented at the moment when rejecting the residue of the food; IV, paramecia; V, kolpoda; VI, trachelia fasciolata, marching on microscopic vegetables.

ANIMAL KINGDOM.

FIRST PRIMARY DIVISION.—OSTEOZOARIA, OR A. VERTEBRATA.

An internal skeleton. A cerebro-spinal nervous system. The organs of the life of relation symmetrical in relation to a straight median plane.

ALLANTOID VERTEBRATA.

Pulmonary respiration from birth; never gills.

Organs of lactation. Hot Blood. Circulation complete, and heart with four cavities. Pulmonary respiration simple. Lobes of the cerebellum reunited by an annular protuberance. Lower jaw articulated directly with the cranium. The body generally covered with hairs. Viviparous.

Class—Mammals.

Examples.

Man.
Ape.
Dog.
Horse
Whale.

No organs of lactation. Encephalon without an annular protuberance. Lower jaw united to the cranium by one or two intermediate bones. Oviparous.

Circulation complete, and heart with four cavities. Respiration double. Blood hot. Body provided with feathers.

Class—Birds.

Examples.

Eagle.
Sparrow.
Cock.
Ostrich
Duck.

Circulation incomplete. Heart divided generally into three cavities. Blood cold. Body covered with scales.

Class—Reptiles.

Examples.

Tortoise &
Turtle.
Lizard.
Snake.

ANALLANTOID VERTEBRATA.

Branchial respiration in youth, or even during the whole of life.

Lungs in the adult. Body naked. Metamorphoses when young. Heart with three cavities.

Class—Batrachia.

Examples.

Frog.
Salamander.
Proteus.

No lungs, nor metamorphoses. Heart with two cavities. Body in general covered with scales.

Class—Fishes.

Examples.

Perch.
Carp.
Eel.
Skate.
Shark.

SECOND PRIMARY DIVISION.—ENTOMOZOARIA, OR A. ANNULATA.

No internal skeleton, but in general a tegumentary skeleton, composed of moveable rings. No cerebro-spinal axis. Central nervous system composed in general of a series of ganglions reunited in pairs in the middle line of the body, so as to constitute a long straight chain. The different organs symmetrical in respect of a straight median plane.

ARTHOPODARIA, OR A. ARTICULATA.

Body provided with articulated organs of locomotion. Ganglionary system very well developed.

Aerian respiration effected by means of tracheæ or pulmonary pouches.

Body composed of a head, thorax, and abdomen, distinct, & provided with 3 pairs of limbs. Tracheæ. A vascular system scarcely existing.

Class—Insects.

Examples.

Cockchafer, or May Bug.
Grasshopper & Locust. Fly,
Bee, Butterfly.

Body composed of a head and of a series of thoracic abdominal rings. Limbs, 24 pairs in number or more. Tracheæ. An arterial vascular system, well developed.

Class—Myriapoda.

Examples.

Scolopendra.
Iulus.

Head confounded with the thorax. 4 pairs of limbs. Sometimes tracheæ & sometimes pulmonary sacs. Vascular system in general sufficiently developed.

Class—Arachnides.

Examples.

Spider.
Scorpion.
Spinner.
Mite.

Aquatic respiration by means of gills, or by the skin. A vascular apparatus very well developed. In general 5 or 7 pairs of limbs.

Class—Crustacea.

Examples.

Crab. Shrimp.
Lobster. Cirrhipedes.
Squilla.

VERMES, OR WORMS.

Body deprived of articulated organs of locomotion. Ganglionary system but little developed or rudimentary.

Respiration almost always branchial. Blood almost always coloured. Nervous system very distinct, and forming a ganglionary chain; median. Bristle-bearing tubercles, serving generally as limbs.

Class—Annelides.

Examples.

Nereid. Earth-worm.
Serpula. Leech.

Respiration cutaneous and vague. Blood almost always colourless. Nervous system more or less rudimentary and lateral. A median ganglionary chain is never found.

Cylindrical body without organs of locomotion, *ventouses* (suckers); very distinct annular divisions. Digestive tube simple; open at the two extremities of the body. Sexes dioïc.

Class—Helminthiæ.

Examples.

Ascarides.
Strongyli.

Body flattened, covered with vibratile cilia, no locomotive appendages,—scarcely annulated. Digestive cavity complex, with a single external aperture.

Class—Turbellaria.

Examples.

Nemertes.
Planaria.
Fasciola.

Body flattened, strongly annulated, and without locomotive organs. Digestive cavity complex, and having no anus. Sexes monoïc.

Class—Cestoides.

Example.

Tænia.

Body annulated, and having anteriorly lobes provided with vibratile cilia. Digestive cavity tubular, and open at the two extremities of the body.

Class—Rotatoria.

Examples.

Rotifera.
Brachion.

THIRD PRIMARY DIVISION.—MOLLUSCA, OR MALACOZOARIA.

No internal articulated skeleton, nor external annular skeleton. Body sometimes naked, sometimes covered with a shell. No cerebro-spinal axis. Nervous system composed of ganglions, whose reunion never forms a long straight median chain. The principal organs symmetrical with respect to a median plane generally curved.

MOLLUSCA, PROPERLY SO-CALLED.

Nervous system composed of several ganglions, reunited by medullary cords. Generation oviparous.

A head distinct, furnished with various appendages, in general having eyes, generally also a univalve shell, never bivalve.

Organs of locomotion placed around the mouth, having the form of tentacles or arms.

CLASS—CEPHALOPODA.

Examples.

Octopus.
Sepia.

Organs of locomotion placed on each side the neck, and having the form of oars.

CLASS—PTEROPODA.

Examples.

Hyalæa.
Clio.

An organ of locomotion occupying the lower aspect of the body, and having the form of a foot or fleshy disc.

CLASS—GASTEROPODA.

Examples.

Snail.
Whelk.
Cowry
or Cypræa.

No distinct head. A bivalve shell.

CLASS—ACEPHALA.

Examples.

Oyster.	Solen, or
Mussel	Razor Fish.

MOLLUSCOÏDEA.

Nervous system rudimentary or absent. Reproduction is effected in general by *bourgeons* or granulations, as well as by eggs.

Respiration taking place by means of internal branchiæ. No protractile tentacles around the mouth. A vascular system and a heart.

CLASS—TUNICATA.

Examples.

Ascidia.
Biphora.

Respiration taking place by means of external branchiæ, forming around the mouth a corona of tentacles, ciliated and protractile. No vascular system or heart.

CLASS BRYOZOARIA.

Examples.

Plumatella.
Flustra.

FOURTH PRIMARY DIVISION.—ZOOPHYTES.

In general no articulated skeleton, neither internally nor externally. Nervous system rudimentary or absent. The various organs disposed in a manner more or less radiated in relation to an axis or a central point, whether in the adult state or only when young.

RADIATA, OR RADIATED ANIMALS.

Body offering a well-marked radiated disposition, whether as a whole or in its principal parts. Almost always prehensile appendages, such as tentacles, arranged in a corona around the mouth.

Animals made for reptation. The surface of the body provided generally with small tentacles terminated by suckers. In general the anus opposed to the mouth. Teguments generally very hard, and often armed with spines.

Class--Echinodermata.

Examples.

Holothuria.
Asterias, or Sea-Star.
Echinus, or Sea-Urchin.

Animals formed for swimming. The body in general enlarged in the form of a disc or of a contractile sac. Tissues very soft, and seemingly gelatinous. Anus replaced by pores or by the mouth itself.

Class—Acalepha.

Examples.

Medusæ.
Beroe.

Sedentary animals, living almost always fixed to the soil, and having no special organs of locomotion. Digestive cavity with a single orifice. Individuals generally aggregated and protected by a horny or calcareous case.

Class—Corollaria or Polyps, properly so called.

Examples.

Actinia.
Caryophyllia.
Astrea.
Coral.

SARCODARIA.

Bodies offering a spherical disposition rather than radiated, and becoming shapeless often by the progress of age. Prehensile appendages almost always present.

General form that of a spheroid in the young and adult. Generally vibratile cilia or flabelliform appendages, serving for swimming. Body hollowed out into several internal cavities performing the functions of stomachs.

Class—Infusoria, properly so called.

Examples.

Monads.
Amœbæ.

General form spheroidal only in the young, and becoming irregular and indeterminable at last. In the adult no appearances of sensibility or locomotion. The body followed out into canals, and supported by silicious, horny or calcareous spicules.

Class—Spongiaria.

Examples.

Sponge.
Spongilla.

IDEAS

ON THE ORGANIZATION OF ANIMALS BELONGING TO THE DIFFERENT CLASSES OF THE ANIMAL KINGDOM.

DIVISION FIRST.

VERTEBRATE ANIMALS.

§ 383. The vertebrate animals,* so named by reason of the presence of a vertebral column forming the essential part of the skeleton, are of all animals the most perfect; and, as was to be expected, those also (§ 346) in whom the organs are the most numerous and the most complex.

They possess an internal skeleton, by which means (?) they attain a size never reached by the articulata, mollusca, and zoophytes; and to this skeleton may be ascribed, no doubt, in part at least, the vigour and precision of their movements.

This internal skeleton, to which there is nothing analogous in the other great sections of the animal kingdom, is generally composed of bones, and is arranged nearly as in man; nevertheless, as in the skate, the skeleton may remain cartilaginous, and there are fishes in which it is all but membranous. We have already studied the skeleton carefully (§ 259 to 282). The part which is never absent is the vertebral column and cranium; other parts may be, and often are, deficient: the ribs are wanting in frogs; the sternum in serpents, &c. But it is especially in the limbs that varieties of formation are observable; these are sometimes wholly absent, as in the coluber or common snake; sometimes they are merely diminished in number, and in aquatic animals this is observed chiefly in respect of the posterior limbs, whilst in land animals it is the opposite. As regards the modifications the limbs undergo, the reader is referred to § 289 to 295, in which sections these matters are fully treated of. The caudal portion of the body being especially of use in swimming, is more fully developed in fishes than in other animals; important in the action of flight, it presents a structure sufficiently constant; whilst in terrestrial animals it loses much of its importance, and is not unfrequently wholly absent.

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* In this sketch of the general type of the vertebrata, we have taken no account of the *amphioxus*, whose organization is extremely low in the scale; for in this eccentric being (which in its character approaches fishes), most of the characters peculiar to this great section or division of the animal kingdom are wanting.

In animals low in the scale of the vertebrata, it frequently happens that the various germs or distinct nuclei of which the bones are originally formed do not coalesce, but remaining distinct, cause it to appear as if the skeleton, and especially the cranium, were formed on a more complex plan than in the higher order of mammals. This however is not the case, since they are all formed on one plan, the difference, which is only seeming, not real, depending on the non-union of the separate germs or nuclei composing the bones in every young animal. It is in fishes and reptiles that we find this most to prevail, and hence the difficulty of reducing the separate pieces to their analogues in the higher animals, and especially in man.

§ 384. It is the nervous system, and especially its central portion, which is most highly developed in mammals; they surpass, probably for this reason, in sensibility and intelligence all other animals.

The cerebro-spinal axis has in all the same general form and relations as in man. Situated on the dorsal aspect of the body, and above the digestive tube, protected by the cranium and vertebral column, it consists uniformly of a *brain*, composed of two hemispheres, two optic lobes, a cerebellum, and a spinal marrow; these structures seem to become smaller and more simple as we descend from man to fishes. The nerves of relation are generally arranged as in man; arising or connected centrally with the cerebro-spinal axis from a double root, on the posterior of which is a ganglion, they form the nerves of sensation and motion, with consciousness. The nerves of the viscera are, on the other hand, connected with the sympathetic or ganglionary system, but this system establishes relations with the cerebro-spinal axis by means of numerous filaments of communication with the nerves of sensation and motion.

Finally, the organs of sense are always five in number, and their arrangement is much as in man.

§ 385. The digestive apparatus presents but few important differences in this great division of the animal kingdom: the orifices of the digestive tube are always remote from each other; the jaws move vertically or in the axis of the body, and not laterally, as in the annulata; the intestine is secured in the abdomen by a mesentery (§ 45): and the chyle, the product of digestion, is absorbed by peculiar vessels, which convey it into the veins, and thus into the mass of blood.

§ 386. The blood, much richer in globules and redder than in other animals, reaches the heart by the veins. It enters an auricle, then passes into a ventricle, and by its means is wholly or in part transmitted to the organs of respiration, the lungs. In general, the blood returns to the heart before its transmission to other parts of the body; but sometimes it proceeds directly to these, and its circulatory movement is determined in some cases by an auricle and ventricle only; in others, by two auricles assisted by one ventricle; and in others, by a heart composed of two auricles and two ventricles (§ 107, 108, 109). The respiration in this class of animals takes place in a cavity of the body internally, but it is not always *aerian*, as in man, being performed sometimes by lungs, sometimes by gills.

Of the secreting organs found in man, there are two which are always present in the class vertebrata: these are the liver and kidneys. The presence of a pancreas and spleen is also very uniform.

§ 387. Nature thus seems to have followed one plan in the construction of the vertebrata, yet they differ much from each other, and hence the necessity for subdividing this great primary division into five classes: namely, mammals; birds; reptiles; batrachia; fishes.

OF THE CLASS MAMMALIA.

§ 388. This class is composed of man, and of all the animals which most nearly resemble him in the most important points of their organization. By their proximity and utility to man, their higher intelligence and organization, they naturally place themselves at the head of all that lives.

For the most part, a mammal may readily be distinguished from every other animal by its external characters, even by the uneducated; but not always, for to this day such persons mistake a porpoise or a whale for a fish, than which there cannot be a greater error in point of fact.

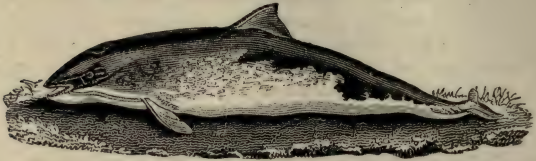

Fig. 193.—Porpoise; Phocæna Communis.

§ 389. *Development of the Function of Lactation.*—That which perhaps is the most remarkable in the history of the mammals is their mode of lactation, by which is meant the mode of nourishment of the young. They are viviparous, and the young from birth depend immediately on the nourishment they receive from the mother; unlike the ovipara, which are at birth all but wholly independent of their parent, in respect at least of nourishment.

The milk intended for the nourishment of the young is formed of water holding in solution sugar of milk, casein, some salts, with a little free lactic acid, holding in suspension globules of butter. Its qualities vary in different animals, and may be modified by the food of the mother. By evaporation it leaves from ten to twelve solid parts of one hundred.

The secreting glands of this alimentary fluid are the mammæ, of which, in the male, there exist only the rudiments. They are peculiar to the class mammals, and hence their name. Their number is in relation to that of the young. In apes, the elephant, goat, hare, there are two; in the cow, horses, doe, there are four; in the cat, eight; in the pig and rabbit, ten; in the rat, ten or twelve; in the agouti, twelve to fourteen. They vary also in their position: in the apes and bats they are placed on the chest, as in woman; in most carnivora, they are situated on the abdomen as well as on the thorax; and in the mare, cow, ewe, &c., they are placed still further back, close to the articulations of the hinder extremities.

In some the young are born with the eyes open, and are ready at once to seek their nourishment; but a great number are born with the eyes closed, and in a state of great feebleness, so that they can scarcely move; and some being born as it were before their term, could not live, were they not to attach themselves to the tit of the mother, to which they remain as it were suspended. In such animals generally, thus imperfectly developed at birth, the integuments of the lower part of the belly form a pouch in front of the mammæ, in which the young are lodged for a time. This structure characterizes the opossums of the New World, and the kangaroo and other marsupial animals of Australia. The young, placed in this pouch by the mother, attach themselves each to a nipple, and remain suspended there until sufficiently strong to leave the pouch, to which, however, they return as to a place of safety, until sufficiently grown to act for themselves.

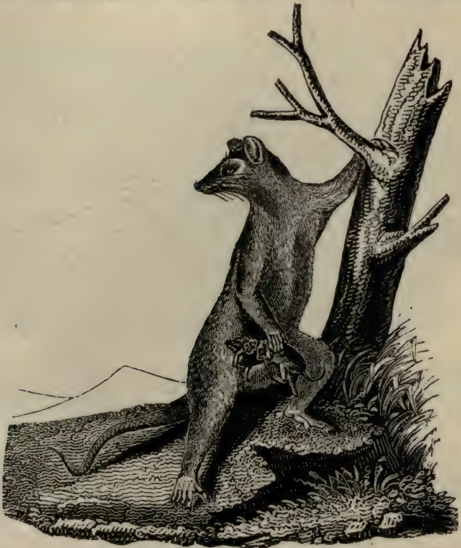

Fig. 194.—The Opossum.

§ 390. *Integuments.*—In a certain number of mammals the skin is naked—that is, it is not secured from harm by any protecting organs,—but in the greater number we find *hairs;* and so constant is this fact, that M. de Blainville proposed to name them *pilifera,* in contradistinction to *pennifera* and *squammifera*—that is, birds and fishes.

The hairs are formed by small secreting organs lodged in the skin, or immediately beneath it. Each hair is formed in a small ovoid pouch, with white resisting walls, communicating externally by a small opening; this pouch is termed the *capsule.* The interior of this cavity is lined by a membrane, sometimes reddish, sometimes diversely coloured, and considered to be a continuation of the *rete mucosum* of the skin; and at the lower part of this capsule is a conical papilla or *bourgeon,* which receives the nerves and bloodvessels, and which forms the hair. The substance forming the hair has the greatest analogy to dried mucus. Under the microscope the hairs seem to be formed of small cones or cornets, jointed into each other; but generally they resemble a simple horny

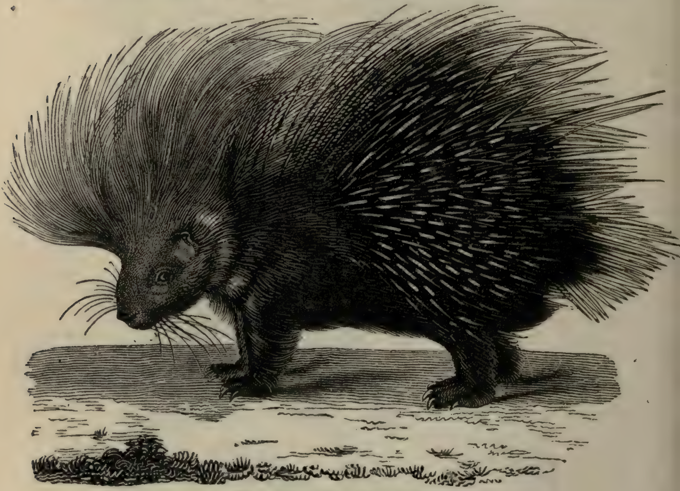

Fig. 195.—The Porcupine.

tube, filled with a pulpy matter. They vary in form, being in most animals cylindrical, and larger at their base than at their summit; in others more or less flattened or lamellated, like sprigs of grass; sometimes their surface is smooth, sometimes roughened with asperities, or having a moniliform aspect; finally, they differ in form and elasticity, not only in different animals, but even in different parts of the same animal.

From these circumstances, the names given the hairs differ, being called barbs, or quills, or bristles, or simply hair. Wool is a sort of hair, very long and tortuous; fur is a still finer form of hair concealed beneath a covering of ordinary hair.

The colour of the hair, which varies so much, may yet be referred to modifications of white, black, brown-red, and yellowish; it seems to depend on the presence of a coloured fat, soluble in boiling spirits of wine; when this is extracted by the action of the above solvent, the hair becomes of a greyish yellow colour. In white hair a white-coloured oil is found, and in red hair, oil of a reddish colour; in black hair a blackish oil, somewhat blue, from the presence of sulphuret of iron.* Sometimes the hairs have the same colour throughout their whole length; sometimes they are darker at their base than towards their summits, and sometimes they present a series of white and coloured rings. Moreover, their colour varies much in different parts of the body, and the general disposition of these tints constitutes what is nominally called the fur (*pelage*). Generally the colours are much darker towards the back, and when there are spots, these are almost always disposed symmetrically on the sides—that is, so long as domestication does not exercise its influence, for then the colouring of the robe presents often the greatest irregularity.

The fur is generally the same in both sexes, and generally varies but little at different ages. Yet in some, the young have spots and a variety of shades, which disappear in the adult, and it not unfrequently happens that the colour of the mammal changes with the seasons.

Generally the hairs fall annually, in spring time or in autumn, to be replaced by others. This kind of moulting occasionally occurs independent of any great change in the colour or character of the hair; in other animals it is different. The common squirrel, for example (Fig. 118), whose fur is of a deep red in summer, becomes of a fine greyish-blue tint in winter. It is at this season that the hair of mammals becomes much thicker, having underneath the fur in much larger quantity. Climate also plays its part in modifying the fur or hairy covering of the skin; hence we seek in cold climates chiefly for the skins of animals supplying the valuable furs of commerce: Siberia and North America are the true fur countries.

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* There exists also in different kinds of hair, sulphur, which may readily combine with lead to form coloured sulphurets. It is in this way that the hair may be dyed by the use of leaden combs, or by the application of salts of lead, mercury, &c., the sulphuret which is then formed being of this colour.

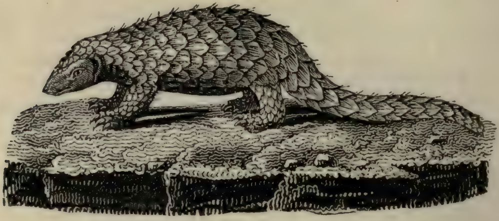

Fig. 196.—The Pangolin (Scaly Ant-eater), or Manis.

When the hairs grow extremely close together, they seem to become matted, and to form those horny plates covering the bodies of some mammals, as the pangolins (Fig 196) and the cuirass of the armadillo. Anatomists also consider nails and horn as having the same origin.

§ 391. *The Skeleton.*—The general form of the body is determined by the skeleton, but this must not be extended to the outline in every instance; the hump of the camel, and the dorsal fins of whales, are not supported internally by any portion of the skeleton (Fig. 197). The skeleton presents always the greatest analogy with the human, which we have already studied (§ 269, &c.) The differences may be reduced, 1st. To the absence of the abdominal limbs in the fish-shaped mammals called cetacea (Fig 193). 2nd. In the diminution of the number of the fingers and toes, and the absence of collar bones in those in whom the limbs serve merely as instruments of progression and support. 3rd. To some varieties in the number of the vertebræ, especially of the caudal. 4th. Inequalities in the relative size of various bones.

§ 392. *Conformation of the Head.*—In the form of the osseous head, the size of the cranial capacity, compared with the area of the face, is supposed to be in the ratio of the intelligence, with certain exceptions; as we recede from man, the face becomes comparatively larger, and the cerebral cavity smaller, proportionally to the face; the orbits are directed more outwards, and cease to be distinct from the temporal fossæ; and the occipital condyles, which in man are found at the base of the cranium, and which form the plane by which the head rests on the vertebral column, recede more and more, until they come to be placed almost on a line with the axis of the body. The same happens with the jaws. Still, we find always the same bones, the same form of articulation of the lower jaw; between its condyles and the temporal bone there is no intermediate bone, as in birds, reptiles, batrachia, and fishes.

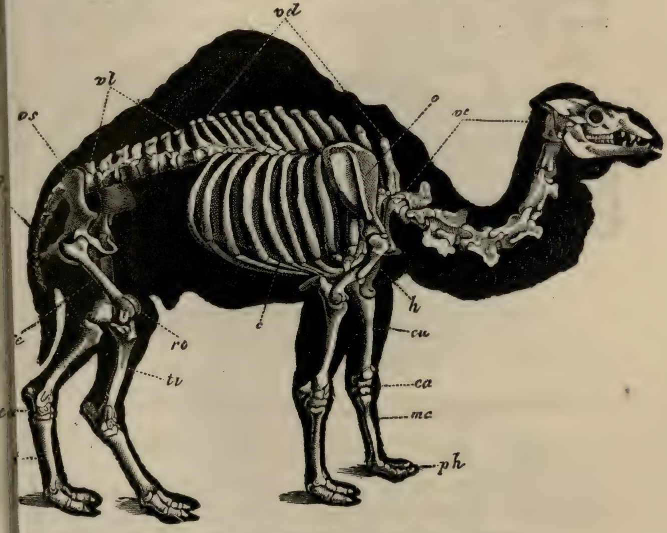

Fig. 197.—Skeleton of the Camel. (See page 141.)

§ 393. Various mammals are provided with horns. These are sometimes mere appendages of the skin, and seem to be formed of the hair matted together; this is the case as regards the horn or horns of the rhinoceros; but generally it is otherwise, and it is a prolongation of the frontal bones, which forms the axis of these horns. All mammals provided with such horns are ruminants. Sometimes the osseous protuberance remains covered with the common integument, and continues so; this happens in the giraffe (Fig. 271). In some, the skin which covers the osseous core or axis disappears, and leaves the bone exposed; which, after being so for a time, falls or is thrown off, to be replaced annually by another growth: such are called antlers, and are found only in the deer kind (Fig. 203); finally, in others the osseous axis is never shed, but continues to grow during the life of the animal, covered with a kind of sheath composed of an elastic substance, especially called *horn*, which grows by layers, and is analogous to nail and hair. The term *hollow horns* is given to horns thus covered with a horny sheath, formed seemingly of agglomerated hairs, and found in different species of the goat (Fig. 202), ox, sheep, and antelope. It ought further to be remarked, that in all these animals, with the exception of the antelope, the osseous axis of the horn is hollowed out into cells communicating with the frontal

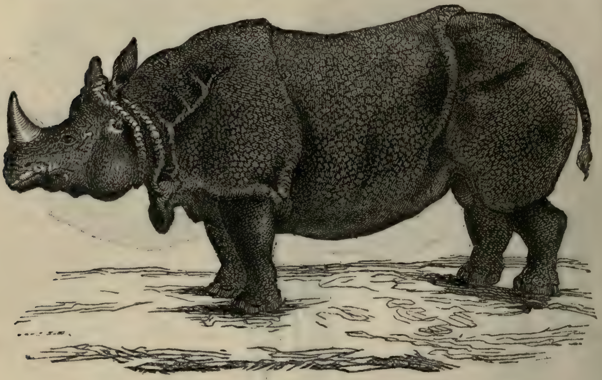

Fig. 198.—Rhinoceros of India; a single-horned Rhinoceros.

sinuses, and thus receiving into their interior the external air.

[The double-horned rhinoceros, a South African species, discovered by Burchell. The double-horned rhinoceros was re-discovered by Sparrman, after its memory had been lost to Europe since the days of Trajan and Severus. It was known to the poet Martialis, who described its *double-horn*. But having been lost to Europe for so many centuries, commentators on Martialis suggested that the poet's text had been corrupted, and upon this they introduced many ingenious alterations, not one of which was true.—R. K.]

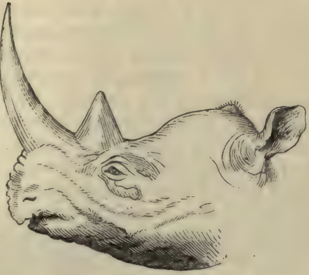

Fig. 199.—Double-horned Rhinoceros.

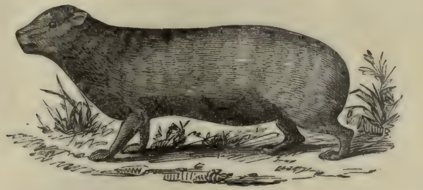

Fig. 200.—Klip-das.

[The Cape Dassar, or hyrax. Cuvier had the merit of transferring this curious little animal (not larger than a rabbit) from the erroneous position in which all preceding zoologists had placed it, to the order pachydermata.—R. K.]

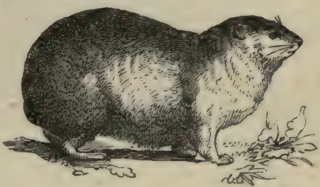

Fig. 201.—The Cape Dassar, or Hyrax,

The mode of formation of the horns called antlers is as follows:—At a certain age there appears a growth of bone on the frontal bone, resembling what medical men call an exostosis, or the callus of fractured bones. These protuberances, which are very compact, grow rapidly, and carry the integuments with them; they are also very vascular. After a time, a series of osseous tubercles begin to form around the base of the osseous horn, which increasing, obliterates the blood-vessels, thus cutting off the supply of blood to the integuments covering the antlers. The integuments drop off consequently, and disappear, leaving the antler itself exposed. And now the antler itself dies, as it were *necrosed*, and ends by being detached from the cranium. In twenty-four hours after this, a thin pellicle covers the surface from which the antler had been detached, and soon a new prolongation begins to grow in the place of the one which has been shed. Generally, the new antler is greater than that to which it succeeds, and its branches are larger and more numerous; but it is of no longer duration than the first, and it undergoes the same changes.

With one exception, the reindeer antlers grow only in the male. The phenomenon has obvious sympathies with the organs of reproduction, for they persist for more than a year in those animals in which the rut does not come to a crisis and is limited. It is periodic, and occurs in the spring.

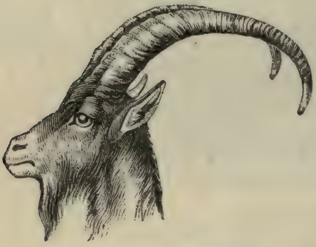

Fig. 202.—Head of the Goat.

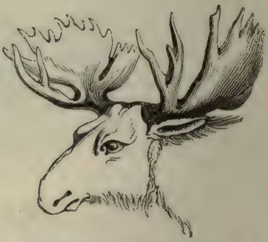

Fig. 203.—Head of the Élan, or Northern Elk.*

§ 394. The extension of the nose in the elephant into a flexible and dexterous proboscis is a modification of the organ well deserving notice. The proboscis of the elephant is, in fact, an extension of the nostrils, forming a double tube, and fitted to perform the office of a hand and a nose. By it water and food are conveyed to the mouth, and air to the lungs; a fibro-tendinous membrane lines it throughout, and to this and to the forehead and integuments are attached thousands of small muscles [or as some view the structure, of two layers of

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* This must not be confounded with the Eland of South Africa, which is an antelope.

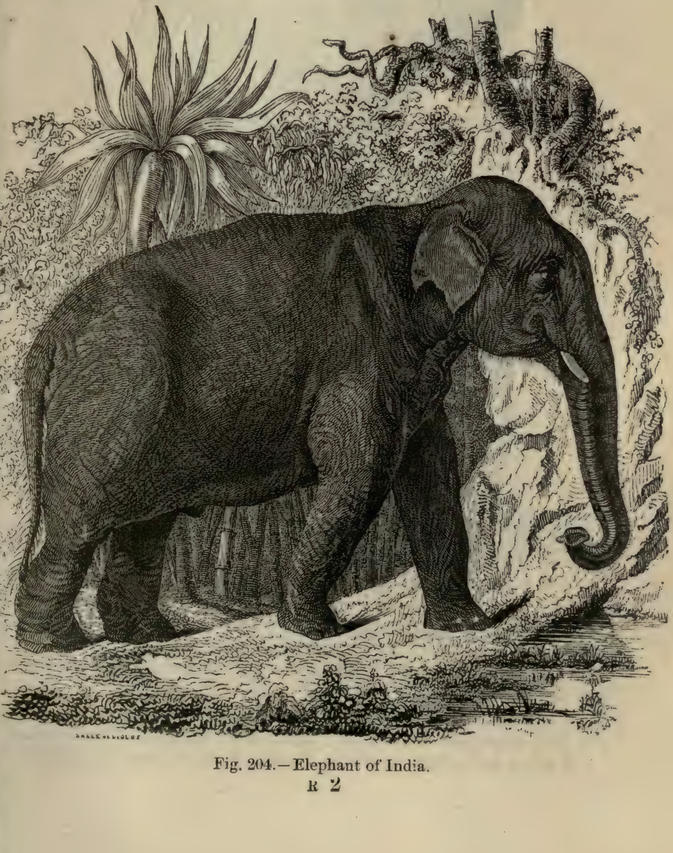

Fig. 204.—Elephant of India.

muscles only—R. K.], so arranged as to elongate and shorten the instrument in every conceivable manner. A cartilaginous and elastic valvule exists superiorly, so as to cut off, at the will of the animal, all communication between the proboscis and the true nostrils superiorly; a finger-like appendage terminates this remarkable instrument inferiorly. The enormous weight of the head renders a proboscis necessary to the existence of the animal, without which it could neither feed nor drink.

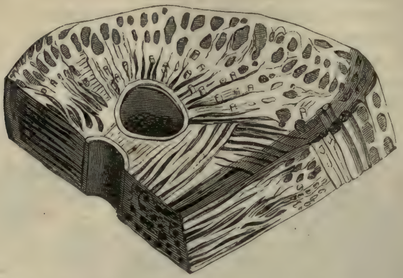

Fig. 205.—Section of the proboscis of the Elephant.

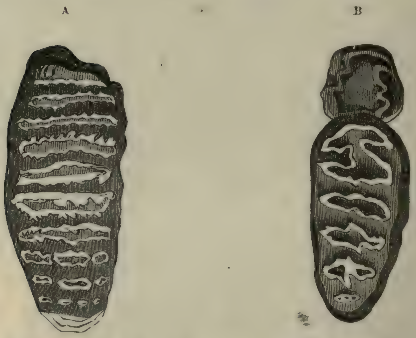

Fig. 206.—Molars of the Elephant :—A, Asiatic; B, African.

The elephants are the only animals which have a proboscis, but there are others in which the nasal organs are prolonged into something analogous. Such are the tapirs (Fig. 208). The desmans (Fig. 209), small insectivorous animals, allied to the *musaraignes,* shrew mice, but adapted for swimming with ease, and searching for their food at the bottom of burrows dug in beaches, present a similar elongation of the nostrils.

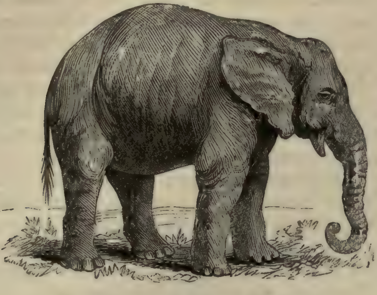

Fig. 207.—South African Elephant.

[South African Elephant, characterized by the great size of its ears and by the configuration of the trituratory surface of the molar teeth (Fig. 206). There are some grounds for suspicion that the elephants of Central and Northern Africa differ specifically from those of South Africa.—R. K.]

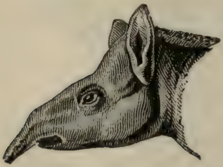

Fig. 208.—Head of the Tapir

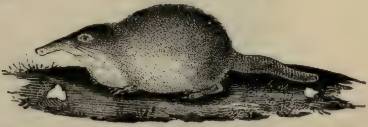

Fig. 209.—The Desman.*

§ 395. *The Trunk.*—The vertebral column presents but slight modifications in the vertebrata, and these are chiefly confined to a difference in the number of the vertebræ.

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* Musk Shrew, Sorex Moschatus, also called Myogale. The Desman of the Pyrenees is the type. There is a Russian or Muscovite species—the Russian Musk Rat.

Again, this difference is chiefly remarkable in the caudal or coccygeal part of the column; in some, as in bats of the genus Pteropus, there exist no coccygeal vertebræ whatever; in other mammals, they number forty, fifty, and even sixty; and in these we also find this distinction,—that the vertebral canal for lodging the spinal marrow and a portion of its nerves still exists in some of these bones, whilst in the terminating ones it is wholly absent. In most mammals the caudal part of the column is but little used for locomotion: in the kangaroo, jerboa, &c., it becomes, with the hinder limbs, a sort of tripod, from which the animal springs with great force (Fig. 103); many American apes use the tail as a prehensile organ of great power, as a fifth hand in fact, by which they dexterously cling to branches of trees (Fig. 110); finally, in the cetacea (whales) it becomes enormous, and serves as their great moving agent in swimming. It is beneath the bodies of these caudal vertebræ that we find the bones shaped like the letter V, which seem to serve as ribs to strengthen the flexor muscles of the tail (Fig. 210). The length of the neck varies also in mammals, although the number of cervical vertebræ is, with few exceptions, the same in all. The exceptions are the aï, which has nine, and the lamantin, which has six. The giraffe and whale, opposed as they are in respect of length of neck, have precisely the same number of cervical vertebræ.

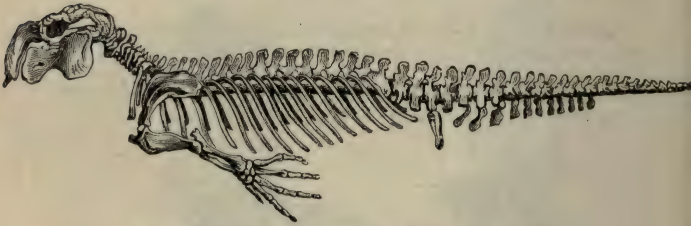

Fig. 210.—Skeleton of a Cetaceous Animal (the Dugong).*

§ 396. The conformation of the thorax or chest varies little; the number of ribs is generally from twelve to fourteen

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[*] I regret that my friend has placed this figure here, for, in point of fact, the Dugong is not a cetaceous animal, as I proved long ago. See Trans. R. S. of Edin. for 1830.—R. K.

pairs; in the horse, however, there are eighteen, and in the elephant, twenty pairs. The sternum, which in general is flat and smooth, is raised into a crest in the bats, as if to accommodate the greatly increased depressor muscles of the wings, thus adapting the animal for flight, an arrangement we find carried to its highest extent in birds. In all this class (class mammals) a muscular diaphragm separates the cavity of the chest from the abdomen.

§ 397. *Limbs.*—In all mammals, with the exception of the cetacea, there are four limbs; two thoracic, and two abdominal or pelvic. In the cetacea there are only two, the thoracic. They are uniformly composed of a basilar portion or base, followed by three principal segments or portions respectively, thus: the arm and thigh, the fore-arm and leg, the hand and foot. The basilar portion of the anterior or pectoral extremity is the shoulder blade, or bone called scapula, whose form varies much according to the character of the movements of the animal. In animals which use their pectoral extremities as instruments of prehension as well as support, the scapulæ are secured in their place by two bones which rest on the sternum; these are the collar bones (Fig. 81); but in such animals as the horse, using its anterior limbs wholly for progression and not prehension, the collar bones are either altogether wanting or reduced to mere vestiges. Some very singular and anomalous animals, also mammals, no doubt,

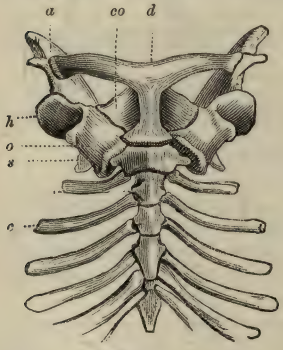

Fig. 211.

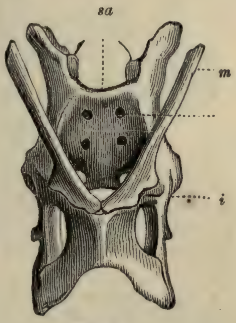

Fig. 212.

differ widely in many respects from the ordinary organization, and in none more than what concerns the structure of the shoulder; we allude to the ornithorhynchus paradoxus and echidna setosa, of New Holland. In these the skeleton of the shoulder more resembles what we find in lizards and in birds than in mammals.*

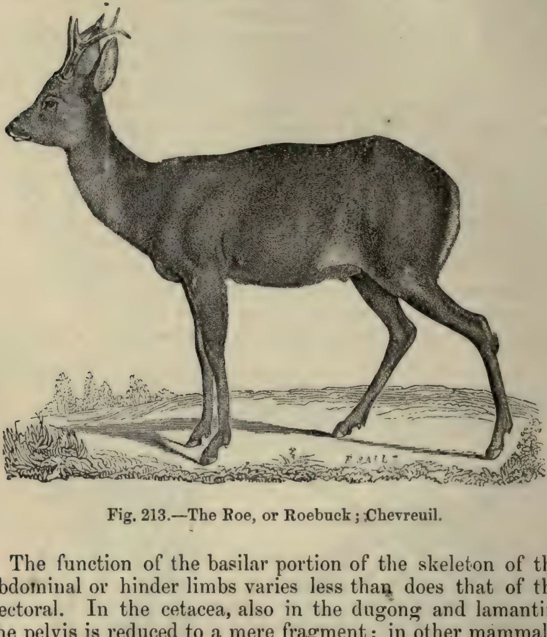

Fig. 213.—The Roe, or Roebuck; Chevreuil.

The function of the basilar portion of the skeleton of the abdominal or hinder limbs varies less than does that of the pectoral. In the cetacea, also in the dugong and lamantin, the pelvis is reduced to a mere fragment; in other mammals, the bones of the haunches (*i*) articulate in an immovable manner with the sacrum (*sa*), and reuniting inferiorly, form a girdle or pelvis, thus surrounding the lower portion of the trunk. The form and dimensions of this girdle vary much, and *cæteris paribus*, the erect position on the lower limb is easier as the pelvis is larger. It must also be remarked, that in the *opossums* and other marsupial animals, the muscles of the abdomen assisting in the formation of the pouch of these animals, are attached to two peculiar bones articulated to the anterior parts of the pelvis, and called by anatomists the marsupial bones* (Fig. 212 *m*).

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* The arrangement of the bones of the shoulder in these singular animals will be best understood by a reference to Fig. 211, in which *d* points to two bones on each side (of which one is not represented here) corresponding to the usual collar bones of mammals; *a* points to the scapula; *h* to the cavity for the articulation of the head of the humerus; *o* the prolongation of the scapula to the sternum, analogous to the *coracoid* clavicle of birds; *co* an osseous piece, the analogue of which has not been determined; *s* and *c* point to the ribs. The meaning of this complexity of the shoulder in this class of animals has never yet been explained.—R. K.

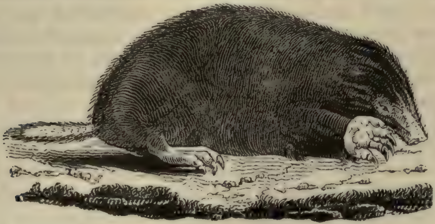
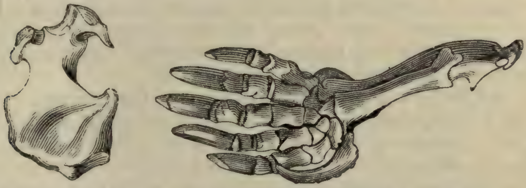


Fig. 214.—The Mole.



Humerus of the Mole.

Anterior Limb and Hand of the Mole.

Fig. 215.

In the arm and thigh in all mammals there is but one bone, the humerus and the femur; in the fore-arm and leg, two bones—the radius and ulna in the fore-arm, the tibia and perone or fibula in the leg. In bats there is a rotula in the arm as well as in the leg. Generally, these leg and arm bones are short and strong, or long and slender, according to the habits of the animal. The mole and chamois may serve as the examples of this modification: strength characterizes the actions of the mole, and swiftness those of the chamois. When the hand no longer serves for prehension, but merely for support, the radius loses its power of rotation on the ulna, and ends by uniting with it so intimately as to be no longer distinguished from it. In the solidungulous animals, the same happens with the fibula and tibia.

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* These bones are present whether the pouch be there or not.—R. K.

The foot and hand vary in mammals according as they are used for prehension, swimming, flight, or walking on ground more or less firm. These circumstances have been already alluded to. The fingers or toes are never more than five, and their number diminishes according as the extremity is more exclusively used for simple progression.

§ 398. *Organs of the Senses.*—The perfection of the fingers and toes as instruments of touch seems to depend on the fineness of the integuments, the form of the nail, and the flexibility of the instrument. In this respect man stands preeminent, in accordance, no doubt, with his higher intelligence (Fig. 98).

§ 399. The organs of the other senses are also analogous in all the mammals to those of man. In those remarkable for the fineness of their powers of smell,—the dog, for example,—the nasal fossæ and frontal sinuses are much enlarged, and the turbinated bones of the nostrils are greatly developed, thus extending the surface of the pituitary membrane, on which the nerves of smell are distributed.

§ 400. In nocturnal animals, the eyes are generally larger than in the diurnal; and in the former the pupil of the eye, when contracting, assumes the form of a fissure, losing its circular character. In moles, whose residence is underground, the eyes become extremely small, and seem in some to be mere vestiges or rudimentary organs; in the aquatic mammals, the lens is, for an obvious reason, spherical. In many mammals there exists a coloured part of the choroid tunic of the eye called *tapetum*, the uses of which are unknown.* Many have a third eyelid placed vertically at the inner angle of the horizontal eyelids. Finally, the direction of the eyes varies much: in man they are directed forwards; but, as we descend in the scale, the direction becomes more and more lateral, and the animal can no longer see directly before him: the sphere of vision for each eye must therefore be distinct.

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* The glaring of the eyes in the dark depends on the presence of this *tapetum*; its colour varies in different animals.—R. K.

§ 401. The organs of hearing offer some modifications in relation to the habits of the animal. In aquatic mammals the external ear is small, or rudimentary, or absent; in the herbivora it assumes the form of an ear-trumpet, becoming more and more detached from the head, and fitted thereby to perform the functions of an acoustic tube. In the nocturnal, the *membrana tympani* occupies more space, and is nearer the surface.

§ 402. *Nervous System.*—As regards the nervous system, in mammals it differs only in respect of the more or less development of its various parts. In all, the encephalic part is very considerable, whether viewed proportionally as regards the nerves or the bulk of the body of the animal; but all the organs composing it do not contribute to this development: thus the cerebral hemispheres are very large, whilst the optic thalami may be very small, or even rudimentary; the reverse of what happens in birds, reptiles, and fishes. The cerebellum is also generally large in mammals, and is composed of a median portion (*processus vermiformis superior*), of two hemispheres, and of a commissure, surrounding the medulla spinalis superiorly, the *annular protuberance.* Moreover, many differences exist among mammals in respect of these organs, as well as regards the depressions and circumvolutions on the surface of the brain. As we descend from man to apes, from these to the carnivora, and from the carnivora to rodents, the brain generally becomes smaller and smaller, and smoother. The face also is developed in an inverse ratio to that of the brain, and the measure of the intellectual faculties may be guessed at by observing this increasing size of the face as compared with the brain.

In the marsupialia and monotremes, the brain seems still further degraded by the absence of, or at least the rudimentary state of, the *corpus callosum,* which in all other mammals unites the hemispheres of the brain to each other.

§ 403. *Functions of Nutrition.*—The functions of nutrition resemble each other throughout nearly the whole of the class; the digestive tube is the organ which shows the most remarkable variety in its arrangements.

Nearly all have teeth (§ 53), which vary in number and form, in accordance with the kind of food they live on. But they may be replaced by whalebone, as in certain of the cetacea (Figs. 15 and 16), or by a horny bill, as in the ornithorhynchus paradoxus; hence the name.

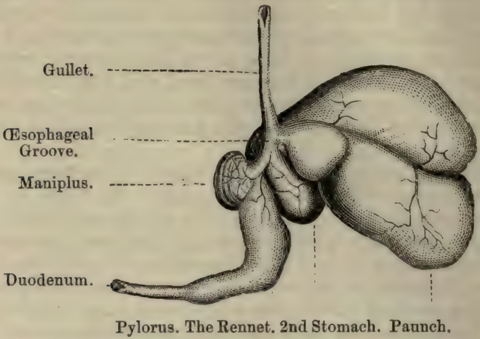
Gullet.
Œsophageal Groove.
Maniplus.
Duodenum.
Pylorus.
The Rennet.
2nd Stomach.
Paunch.

Fig. 216.—Stomach of the Sheep.

§ 404. The stomach is usually simple, as in man (Fig. 24) and the ape (Fig. 5); but in others, as in ruminants, the organ is subdivided into a number of compartments, from the first of which the food, after remaining a certain time there, returns to the mouth by the gullet, to be remasticated (rumi-

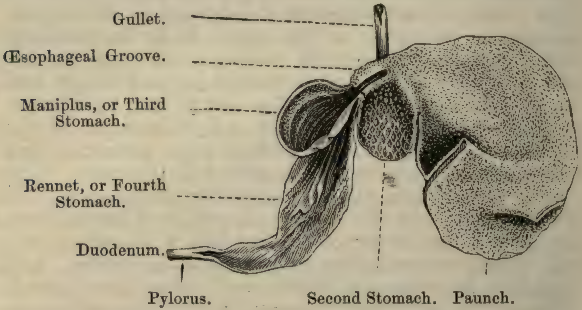
Gullet.
Œsophageal Groove.
Maniplus, or Third Stomach.
Rennet, or Fourth Stomach.
Duodenum.
Pylorus.
Second Stomach.
Paunch.

Fig. 217.—Interior of Stomach of the Sheep.

nation), and thence transmitted into the following compartments, without again passing into the first.

These stomachs, or stomachal compartments, in ruminants are four in number. The first, which is the largest, is called the paunch (Fig. 216); its surface is furnished with papillæ and an epidermic covering (Fig. 217); it fills a large part of the left side of the abdominal cavity. The second stomach, called the king's hood, is small, and looks like an appendage of the paunch. But it differs internally (Fig. 217), being composed of a number of folds disposed so as to form polygonal cells or cellules, like honeycomb. The third stomach, not so small as the second, is called maniplus, from the number of longitudinal folds seen in its interior: finally, the fourth is called the rennet: its property of curdling milk renders it remarkable. The first, second, and third stomachs communicate directly with the gullet, which indeed seems to open equally into the first and second. After being ruminated, the food descends from the gullet into the third stomach by means of a semi-canal, which no doubt becomes complete at the time, thus directing the food in one course only, diverting it from the paunch and second stomach; from the maniplus, it passes into the rennet or fourth stomach, in which cavity digestion is finally completed.

The act by which the food passes when first swallowed into the paunch and thence to the second stomach, but which on being ruminated or remasticated descends only to the third by means of the œsophageal canal, is not an act of intelligence, but one purely instinctive, and perhaps even mechanical, due to the anatomical disposition of the structures. Food of the size it is when first swallowed, opens mechanically the semi-canal, by which the gullet communicates with the first and second stomachs; but fluids and the remasticated food being much finer, do not effect this, and thus pass on by the canal into the maniplus or third stomach. Rumination is generally ascribed to the second stomach, but it appears more probably due to a combined action of the first and second, which, by contracting, forces the bolus again into the gullet, by which it remounts to the mouth.

The paunch is of very great size in the adult animal; in the young, whilst living on the milk of the mother, it is smaller than the rennet, thus showing (?) the influence the food exercises in enlarging the capacity of the organ.

§ 405. The capacity and length of the intestines are much less in the carnivora than in the herbivora, being in many of the former only three or four times the length of the body; whilst in the sheep, for example, it is nearly eight times that length. Generally it terminates by a distinct opening; in the ornithorhynchus, however, the anus opens into a cloaca, or cavity, in which terminate also the urinary organs, resembling birds in this respect. The salivary glands, the liver, pancreas, peritoneum, and its appendages, resemble the same organs in man.

§ 406. The more essential differences exist in the apparatus of respiration and circulation; the heart has always two auricles and two ventricles (§ 92, Figs. 39, 40); the lungs are always composed of cellules, which do not allow the air to escape into the other organs of the body, as in birds. The blood is rich in organized matters, and the form of the globules circular (§ 81, Fig. 36).

§ 407. We have already shown that the mammals differ widely from each other in respect of intelligence (§ 337); and the various instincts bestowed on them by nature to supply the deficiency of a higher intelligence have been already alluded to. It is the class which most interests man, including within it, as it does, so many of our domestic animals; the horse, ox, sheep, &c. So complete, indeed, have been the effects of domesticity over some of these races of animals, that the primitive race seems altogether to have disappeared. The moral as well as the physical characters of the domesticated races are thus affected and altered. The dog, for example, so varied by domestication, may yet have sprung from a single race, neither a wolf nor a jackal, but a dog analogous to the common shepherd's dog, or wolf-dog, as it is sometimes called.

The power by which this complete subjugation of a race of animals is effected seems to be the inspiring them with confidence by kind acts and uniformly good treatment. We must show them that the supply of food depends on us; and if to that we add food of a choice character, artificial wants are thus created, which the animal feels man alone can gratify. Hence his attachment to him;* finally, some are extremely fond of being noticed and made much of.

Confidence and dependence on man being once established, fear may afterwards be superadded; but this must be done with great caution, lest it excite terror and disgust.

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* It is chiefly by means of sugar and other delicacies that horses and deer are taught those extraordinary tricks exhibited in the circus.

But all mammals do not thus readily lay aside their savage disposition, being either less confiding or less sensible to acts of kindness, or it may be that their intellect is lower; but be this as it may, it is evident that any animal, to become completely domesticated, must be disposed to it by the instinct of sociability. No solitary mammal ever becomes completely domesticated, however readily he may be tamed.* Sociability is an essential of complete domesticity, man becoming, as it were, the head of the troupe. A disposition to domesticity may be considered as the extreme development of the instinct of sociability.†

§ 408. Let us now consider the moral and physical influences which domesticity exercises over the domestic races of animals; how, in fact, it produces new varieties.

The physiological law of hereditary resemblances holds true in all animals, man included; the young resemble their parents in conformation, physical and mental qualities, and even in respect of disease itself. But all the individuals of a race do not possess in the same degree the same qualities, moral and physical; and hence arises the possibility of giving to certain qualities a higher and more constant development. Within certain limits, then, man may modify races, by regulating the succession of generations, selecting a type or standard for the new variety he is desirous of creating.‡ By endeavouring thus to develop from generation to generation a certain physical or mental quality, we render such qualities hereditary, at least for a time.

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* The cat may seem an exception to this view, but, in fact, the cat is never completely domesticated.

† The theory of domestication is one of extreme difficulty.—R. K.

‡ The bloodhounds transplanted into America by the Spaniards, employed at first to pursue only men and deer, furnish a remarkable instance of the power of transmitting certain newly-created mental qualities, hereditarily. In different parts of America, as on the central table-land of Santa-Fé, these animals have preserved their original instincts and physical qualities, but amongst the poor inhabitants of the banks of the Magdalena they have become degraded, partly by a mixture with other dogs, partly by a scarcity of food, and in this degenerate race of the bloodhound a new instinct has been developed. The chase in which they have been long employed is that of the white-muzzled Peccari. The skill of the dog consists in moderating its courage or ardour, so as not to attack any individual of the troop or herd of peccaris, but to keep the whole in check. Now it has been observed that these dogs act thus on the very first occasion they hunt the peccari, whereas any strange dog throws himself on them at once, and is devoured in an instant, whatever be its strength.

Even in our own times, guided by interest, men have thus formed new varieties of sheep, oxen, and horses. To Bakewell, for example, we owe the variety of sheep called New Leicester, remarkable for their fattening qualities. The forequarters of the large Wurtemburg variety of sheep, as a valuable sort for the market butcher, weigh from 52 to 55 per 100 of the whole weight; in the New Leicester or Dishley breed, the weight amounts to 70 or even 75. It must be known to all how the quality of the wool is improved by crossing with the merinos of Spain.*

Finally, the various breeds of horses prove these facts respecting the influence of man over the domestic races of animals. Our agricultural breeds of horses owe in part their stature, their forms, and qualities to the race from which they have sprung: but the circumstances in which they are placed when young exert an influence over them no less great. The young resembles the mother more than the father in respect of the size and height; whilst it resembles the father more as regards the feet, speed, courage, &c.

It is essential therefore, in breeding, to select those individuals only which possess the requisite qualities, rejecting their opposites; or, in other words, to breed from those having opposite qualities: in time the new forms become hereditary and general. To attention to these matters the Arab horses owe their grand qualities. The noble breed they call kochlani has its purity secured by authentic legal attestations, during a series of four ages, and the known genealogy of several of these fine animals extends to two thousand years. The English race-horse owes its qualities to a mixture of the Arab stallion with the indigenous mares of England; hence its stature and astonishing rapidity. The abundance and quality of the food, the nature of the climate, the daily cares bestowed on the horse, influence the race much more than is generally supposed: as a proof of this, we may notice the rapidity with which the finest English horses degenerate in certain localities, as in the studs of Kopschan on the borders of Moravia. But the same fact may be observed nearer home. If two colts of the same breed, of Lorraine for example, be placed, one in Flanders the other in Normandy, instead of retaining their resemblance to each other, they will at five years resemble horses of different breeds: the one will grow up a coach-horse, light and elegant; the other an enormous animal, hardly able to trot, but equal to the draught of the heaviest loads. Where nourishment abounds, there the size and weight of the horse increase; opposite circumstances are attended with other results. Fed on strong humid pastures, the horse becomes heavy, and his form and hair coarse; on light soils, and especially if grain be added to his ordinary food, his form becomes light and elegant: finally, the careful grooming bestowed on the English horse contributes to improve his form, and especially the fineness of his limbs. Thus it happens, as in the dog, that varieties may be so multiplied as to make it appear that they must have sprung from more than one species: nevertheless, all these modifications have their limits, beyond which nature will not or cannot go: they never destroy the distinctive characters of zoological species.*

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* It was in 1776 that the superintendent of finances, Daniel Trudiane, attempted first the introduction of the merino into France, and it is to Daubenton, the collaborateur of Buffon, that is due the success of the enterprise.

§ 409. *Classification of the Mammalia.*—There exist, as we have seen, considerable differences amongst the mammalia, and these modifications of structure serve as the basis for the division of the class into groups of an inferior rank, called *orders*. Most of these groups are so distinct as to admit of no doubt in respect of their limits: they constitute, in fact, natural divisions; but in others the line of demarcation is by no means so distinct. Thus a mammal may have points of resemblance so close to two groups as to render it almost indifferent to which it be referred. To some naturalists, differences appear important which are disregarded by others, and hence a want of agreement on the subject of classification has always prevailed.

The method followed here is nearly that proposed by Cuvier. It rests mainly on the differences mammals show in respect of their extremities and teeth, differences which always imply a crowd of others in structure, habits, and even intelligence.

§ 410. Keeping in view the *ensemble* of these characters, the class mammalia may be divided into two groups,—the *monodelphic* and *didelphic*.

The monodelphic or monodelphian are the more numerous, and are distinguished chiefly by their mode of development. At birth they are already provided with all their organs, and before birth they derive their nourishment from the mother by means of a *placenta*. Their brain is more perfect than the didelphian, by the presence of a corpus callosum uniting the two cerebral hemispheres (§ 186). Finally, the walls of the abdomen have no osseous supports attached to the margins of the pelvis, as we find in the second great class of mammals. The mammals thus organized have been subdivided into two groups,—namely, *ordinary mammals* and *pisciform mammals.*

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* Experiments made in this country have led to entirely different results. The various breeds of horses, cattle, and sheep remain unaltered, on whatever pastures they may be fed.—R. K.

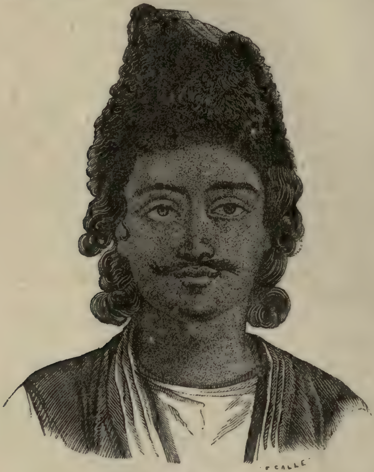

Fig. 218.—Caucasian Race.

§ 411. The ordinary mammals are organized principally to live on solid ground; the skin is provided with hairs. These animals are further subdivided into ten orders: the bimana, quadrumana, cheiroptera, insectivora, rodentia, edentata, carnivora, amphibia, pachydermata, and ruminantia. The first eight of these orders have flexible fingers and toes, with nails covering only the dorsal aspect of the toe or finger, and comparatively small; hence they have been called *unguiculata;* the last two,—namely, the pachydermata and ruminantia, have the extremity of the finger and toe entirely enclosed in a hoof; they are thus called *ungulata.*

§ 412. The order bimana includes only man: in him alone the arms are destined for prehension, the limbs for progression and support in the erect attitude. Thus, the natural position on the soil is unmistakeably vertical. The teeth are of three kinds (§ 52), and have their edges on the same plane; they are frugivorous: finally, the brain is more perfect, more highly developed, than in any other animal.

Though man represents but a single species, yet in his *varieties* he offers many remarkable differences, especially as to colour, features, and proportions; of these varieties, the more remarkable are the white or Caucasian, the yellow or Mongolian, the black or Ethiopian.

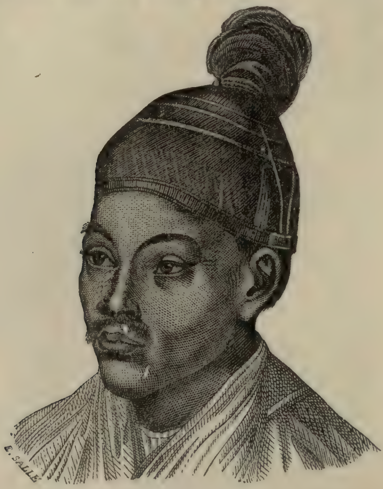

Fig. 219.—Mongol Race.

The Caucasian variety of man occupies all Europe and Western Asia as far as the Ganges, likewise Northern Africa. To it belong the more highly civilized nations. The region of the Caucasus has been supposed to have been the cradle of the race, hence its name. A fair skin, elevated forehead, small cheek-bones, hair varying in colour, but always smooth, together with high intellectual qualities, characterize the race.

The Mongolian variety differs in many respects from the

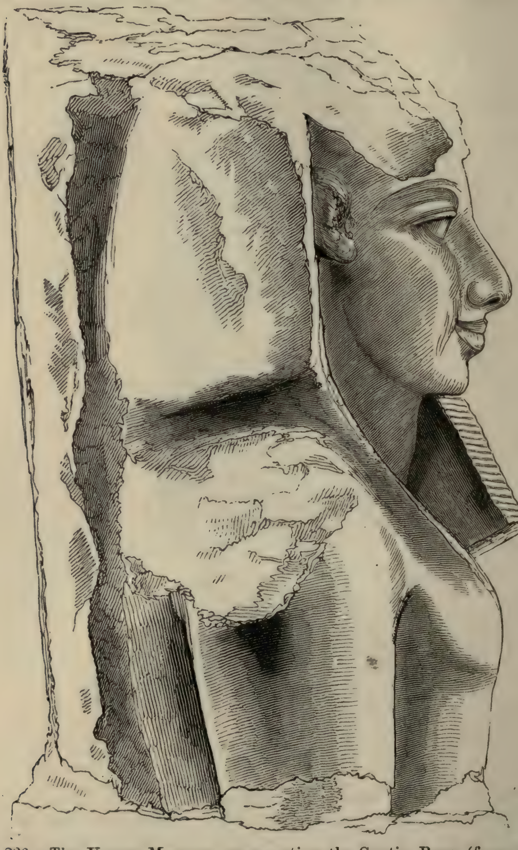

Fig. 220.—The Young Memnon, representing the Coptic Race (from the celebrated bust in the British Museum); copied from my work on the *Races of Men*.—R. K.

Caucasian. The brow is low and square, the eyes small and oblique; cheek-bones prominent, nose flat, little or no beard, hair black and smooth, colour yellow. Their language is monosyllabic. Their original country is Central Asia, ex-

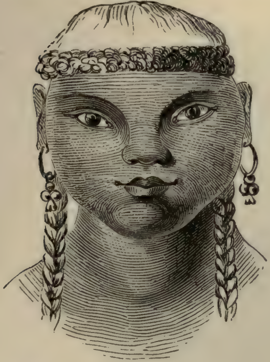

Fig. 221.—Mongol (From Clark's *Travels*.)

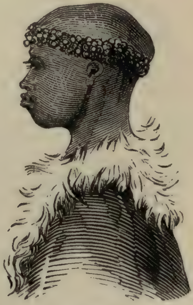

Fig. 222.—Bosjesman, or Yellow African Race.

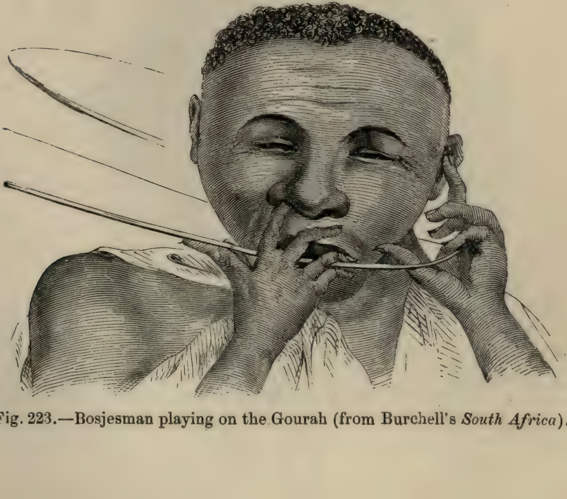

Fig. 223.—Bosjesman playing on the Gourah (from Burchell's *South Africa*).

tending to and including China and the Chinese, the earliest, seemingly, of civilized men. Siberia and Mongolia, the Crimea, Thibet, Japan, the Aleoutian Isles, and even the western shores of Northern America, are all occupied by this race of men.

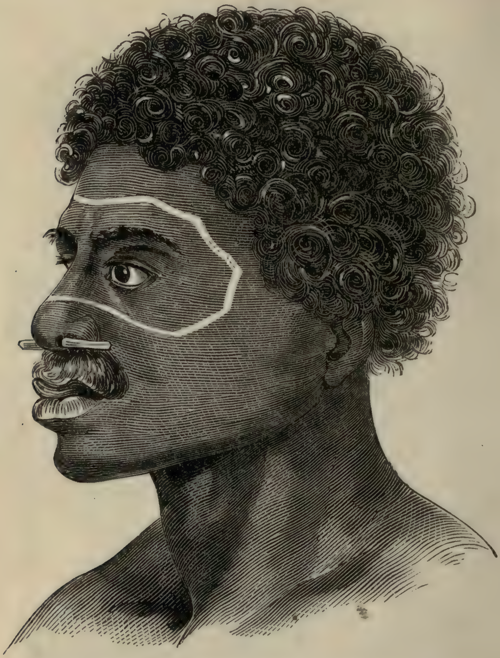

Fig. 224.—The Aboriginal Native of Australia, from Peron.

Some naturalists view the Malays as a distinct race of men; but most view them as a mixture of two races. Lastly, the degraded races known as Laps, Samoides, Esquimaux &c., seem to be related to the Mongol race. A third distinct variety of mankind is the Ethiopic, confined to Africa, south of Mount Atlas, seemingly composed of several distinct races of men, such as the Negro, Bosjesman, Hottentot, Mozambique, &c. It is characterized by the dark colour of the skin, frizzly hair, low and compressed forehead, projecting jaws, large lips, and muzzle-shaped mouth, with

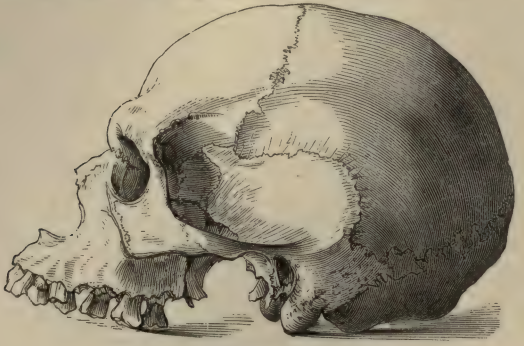

Fig. 225.—The Skull of the Tasmanian.

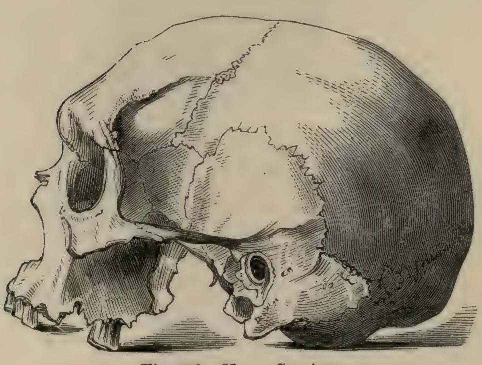

Fig. 226.—Negro Cranium.

other peculiarities, which need not be mentioned here. The primitive population of Australia and of the numerous isles of the oceanic Archipelago, have been viewed by some naturalists as constituting a distinct variety; the Alfourons are but little known.

Finally, the indigenous inhabitants of America have been viewed by many naturalists as a distinct race of men. They are copper coloured, have long, black, straight hair, and but little beard. But some of them have strong analogies with the Mongolian race of Asia, whilst others approach somewhat the form of Europeans. The nose is as prominent as in the European, and their eyes are large and open.

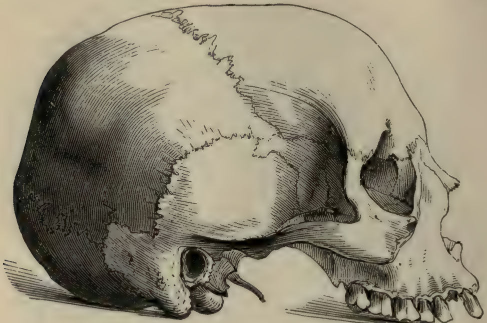

Fig. 227.—Caffre Skull.

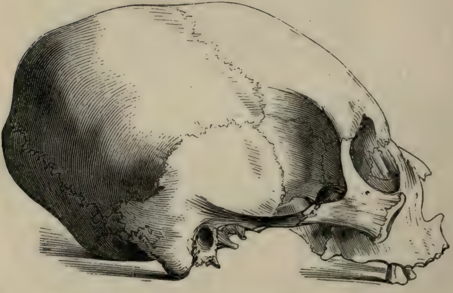

Fig. 228.—The Cherokee Head.

[The cranium of the American race is remarkable for the depression of the forehead, and this character seems to have belonged to the aboriginal races first peopling America. This is proved by the remains of Mexican antiquities and by the drawings of the Aztec race, a race now seemingly extinct. To such an extent was the forehead depressed in that race, that were it not for these drawings and the existence of the same malformation in the Cherooks and other tribes still existing, it might have been inferred that no such race of men could ever have existed.

Hippocrates mentions a race of men with similarly formed heads as inhabiting, in his days, the shores of the Euxine, and recently crania of a similar character have been said to have been found in Germany, in situations implying a high antiquity. A notion has been thrown out by some popular writers that man, at first rude and savage, small brained, and deficient consequently in intellectual powers, has been gradually improved by education and civilization, and that by the culture of his intellectual powers his brain has become enlarged, and with it the cranium. Like all medical theorists (for they are medical men who advocate such hypotheses) they catch at any statement which may seem favourable to their latest hypothesis, wholly regardless not only of its incompatibility with other facts but with their own theories. Such a notion is moreover refuted by all human history, and is absolutely antagonistic with the chronological system which to a man they have adopted.—R. K.]

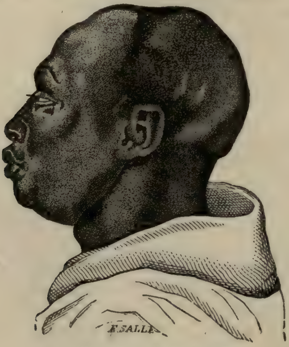

Fig. 229.—Ethiopian Race.

["The term Caucasian was devised by Blumenbach to characterize a certain number of the higher races of man, but he did not attach any theory to it; that has been done by later writers. His arrangement of the races of men was geographical; and although it has certain facts favourable to it, the view is now very generally abandoned.

"Each race seems to have a civilization peculiar to itself; thus the ancient Greek, seemingly now extinct, carried the arts, literature, and even science, or at least philosophy, to a point they have never reached since their epoch; the Coptic race had its own form of civilization, as exhibited in their architecture, sculpture, and painting; the same may be said of the Persian and Mongol. The Western European races are chiefly deficient in imagination and genius. The Negro race has never invented anything.

"Of all the races of man, the most remarkable is the Saabs, or yellow race of Africa: it includes the Hottentot and Bosjesman, properly so called; but travellers affirm that the Australian or Tasmanian stands lowest in the scale of humanity. However this may be, certain it is that most of the coloured races of man become rapidly extinct in presence of the white or European races; and were it not for climate, it is probable that many of the races of man would have been long ago extinct, or nearly so; but nature seems to oppose the transfer of a race from the continent on which it first appeared to another. Thus the English make no progress in reality in India, and from northern Africa all the immigrant races of Phœnician, Greek, Roman, Vandal, &c., have disappeared. The Spanish blood will ere long become extinct in America.

"The anatomical structure of the races of man differs considerably, so that there is not the slightest difficulty in distinguishing their various crania, although popular writers are fond of denying this fact; they are misled by the affiliations which naturally exist amongst the races of man as amongst all other animals; these affiliations show that the races of man now on the globe form one family."—R. K., *Races of Men.*]

§ 413. The order of the quadrumana is composed of those animals which have the great toe so constructed as to perform the functions of a thumb, and which use the four limbs as well for prehension as for locomotion. Like the bimana, they are frugivorous, and their teeth are similar to ours. In this group are arranged the apes (Fig. 110, 133), the ouistiti (Fig. 6), and the makis (Fig. 230).

The apes are animals of small or moderate stature, the muzzle moderately prominent, the neck short, the body slender, and the extremities thin and long. They are covered with long and silky hair, closely set; nevertheless, their resemblance to man is sometimes extreme, and there are some which, when young, have the facial line not more oblique than in the negro; but with age, in some the face projects, becoming a muzzle, resembling that of the dog (Fig. 231). The gestures and tricks of these animals have often a strong resemblance to our own. With the aid of a stick some hold themselves upright, and even walk as we do, but never steady nor assured in their step, so that in the vertical position they always seem constrained and ill at ease. On the other hand, in the forest they display the utmost agility, and this seems indeed to be their natural locality. To arms of great length,

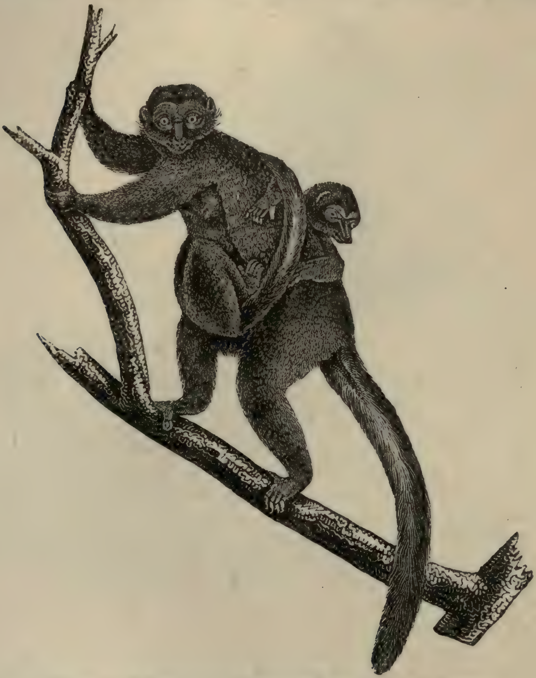

Fig. 230.—White-fronted Makis or Lemur, with its Young.

and feet organized as hands, with an opposing thumb, in some we find in addition a long prehensile tail, so that their activity amongst trees becomes almost incredible.

Apes inhabit only warm countries; a single species* dwells on the rock of Gibraltar; the apes of the New World are all distinct from those of the Old.

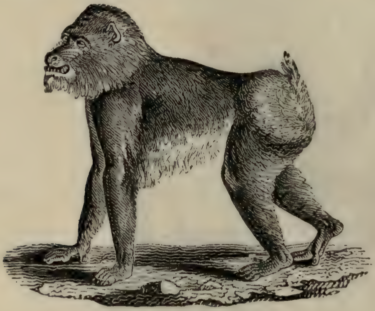

Fig. 231.—Dog-faced Baboon.

§ 414. The order of carnivora is composed of ordinary unguiculated mammals; the form of their dentition is complete, but they have no opposing thumb. According to the mode of life of these animals, their intestinal canal is short; their jaws and their muscles strong, in order to seize and devour their prey; their head from this circumstance seems large. The jaws are short, thus favouring their strength, and the form of the temporo-maxillary articulation proves that the teeth are made for tearing and cutting, but not for grinding or masticating. The canine teeth are large, long, and very powerful; the incisives, six in number in each jaw, small; the molar, sometimes entirely adapted for cutting, in others surmounted with rounded tubercles, presenting no conical points, arranged as in the insectivora. One of these molar teeth is usually much longer and more cutting than the others, and has therefore been called the carnivorous molar tooth; behind these (on each side) are one or two molars, almost flat, and between the carnivorous molar and the canine a variable number of false molars. The food of the animal, whether exclusively carnivorous or mixed with other matters, may be judged of by the varying proportions of these cutting or tuberculated parts of the molar teeth.

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* [Now (1863) reduced to three individuals.—C. C. B.]

Animals of this order have generally the toes armed with claws adapted to hold and to tear their prey; usually also they have no collar bones. This kind of organization is met with in the genera cat, hyæna, viverra, martin, otter, dog, badger, bear, &c.

The genus cat (Fig. 232), which may be viewed as the type of the carnivora, comprises not only the common cat, but also the tiger, lion, panther, lynx, &c.; their jays are short, and are acted on by muscles of extraordinary strength; their retractile nails, concealed between the toes in a state of repose by means of elastic ligaments, are never blunted. Their toes are five in number on the anterior limbs, and four on those behind. Their hearing is exceedingly fine, and the best developed of all their senses. They see well by day and night, but they are not farsighted; in some the pupil is elongated vertically, in others it is round. They make great use of the organ of smell; they consult it before eating, and often when anything disturbs them. Their tongue is covered with horny and very rough points. Their coat is in general soft and fine,

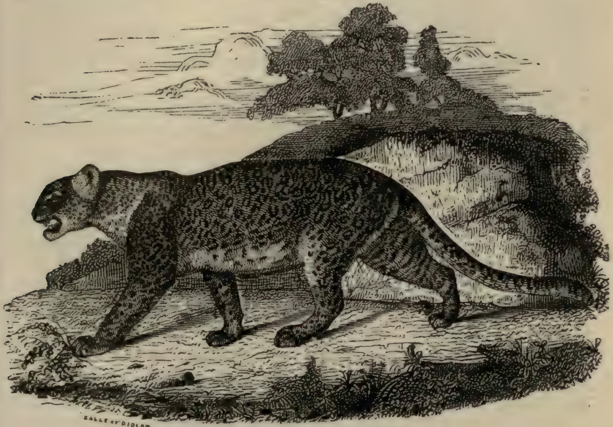

Fig. 232.—The Panther.

and the surface of the body very sensible to the touch; their moustaches especially seem to be instruments of great sensibility. Though of prodigious vigour, they generally do not attack animals openly, but employ cunning and artifice. They never push their prey to flight, but watching by the margins of rivers and pools in covert, they spring at once on their victim.

At the head of this genus stands the lion, measuring frequently twelve feet in length, or over six feet to the setting on of the tail; about three feet in height, and characterized by the square head, the tuft of hair terminating the tail, and in the male by the main which flows from the head and neck. The lion is the most powerful of the carnivora; with a single blow of his fore paw he can break the back of a horse, and a stroke of the tail will strike down the strongest man. Formerly spread over the three great divisions of the Old World, he seems now limited to Africa and Asia.

The animal which some call the American lion belongs to a different species; it is called couguar, and is peculiar to the New World.

The royal or Eastern tiger is an animal more dangerous than the lion, which it nearly equals in strength, but exceeds in ferocity. The hair in the tiger is short and smooth, and yellowish above, with black transverse bands or stripes; it inhabits India, where it does much damage.

The jaguar, not much less than the Eastern tiger, and almost as dangerous, is a native of America, and is found only there. It inhabits the great forests. Furriers call it the great panther, for it is spotted like that animal; the fur being yellow, with four rows of dark spots like eyes ranged along the flanks, with white and black stripes beneath.

The panther (Fig. 232), so remarkable for the beauty of its fur, is found all over Africa and Asia, together with the leopard, which it much resembles; the fur is yellow, with numerous dark spots.

The lynx, also, or cat, is distinguished by a pencil or tuft of hairs surmounting the external ears; the coat or fur is red coloured, spotted with a reddish brown. It is indigenous to temperate Europe, but it has nearly disappeared from populous countries; it is still found amongst the Pyrenean mountains, in the kingdom of Naples, and in Africa. It ascends trees; and, having excellent sight, does much mischief by destroying hares and deer. The ancients ascribed to it a power of vision equal to the seeing through a stone wall—hence the phrase, lynx-eyed.

The common cat comes originally from the forest. In a wild state it is of a brown colour, somewhat greyish, with deeper coloured transverse waves. The tail is annulated with dark rings; the inner side of the thighs and feet, yellowish.

The hyæna is distinguished from the genus cat by the number of toes, which is four for all the limbs, as well as by the enormous strength of the teeth and jaws, and by the claws or nails, which are not retractile during walking. The tail is short and pendant, and underneath the anus is a pouch which secretes a disagreeably-smelling viscous matter. Their gait is odd, and they carry their hind quarters much lower than the fore. They are nocturnal animals, preying on whatever they can venture to attack; cowardly; they disinter the dead, and despise no kind of food. They resort to caverns during the day-time. Their reputation for ferocity is not borne out by the fact. The common hyæna belonged originally to Asiatic Turkey, Syria, and to some countries of Africa.

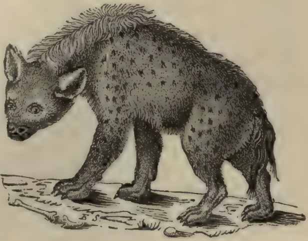
Fig. 233.—The Spotted Hyæna.

The carnivora called putorius or polecat, mustela or common marten, otter or lutra, and some others, are remarkable for the length of their bodies and shortness of their limbs. They are all small, but extremely sanguinary.

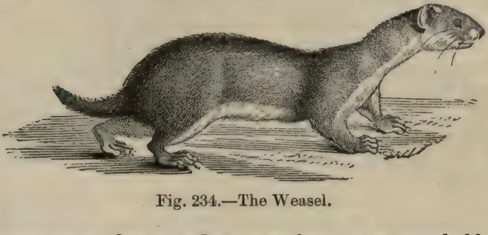
Fig. 234.—The Weasel.

The genus putorius comprises the common polecat, the ferret, marten, the ermine, and several other species, which all have the head rounded, the fur brilliant and soft, the tail long, and anal glands which secrete a fœtid matter.

The martens differ but little from the polecats, and are equally sought after for their fur. The polecat, which does such damage to the poultry, belongs to this genus.

The otter (lutra) has the head depressed and the feet palmated. Otters are aquatic nocturnal animals, inhabiting the margins of rivers and lakes, and subsisting mostly on fishes.

The genus dog comprises the dog, properly so called, the wolf, and the fox. All these animals are characterized by a peculiar dentition, great strength and agility, senses of hearing and smell acute, claws adapted for digging; they show a partiality (some at least) for putrid flesh as food. Their sight is excellent.

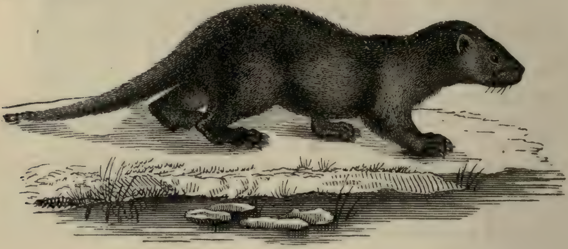

Fig. 235.—The Otter.

The domestic dog is distinguished from the other species by the curved tail. This animal is born with the eyelids closed, and they open only after ten or twelve days; the female has six or seven at a birth, and sometimes even twelve. The duration of life is from twelve to fourteen years; they have been known, however, to live to twenty, and their age is determined by their teeth, which in the young are white, pointed, and cutting, but in the aged blunted, dark coloured, and irregular.

The dog is the most complete conquest which man has made in respect of any animal. The entire species has become domesticated, so that the primitive condition is lost. The wild dogs found in some countries are merely domestic dogs which, being abandoned, have run wild, and recovered some of their primitive savage habits. Some naturalists are disposed to think that originally there may have been several species of the dog, and others imagine the wolf or jackal to be the origin of the domestic dog; but when abandoned on desert isles, the dog never assumes the character of either of these animals. The dogs of people but little civilized have the ears erect, and hence it has been supposed that the shepherd's dog, or wolf dog, is the origin of the domestic dog of all varieties.

The common wolf is readily distinguished from the dog by the tail, which in the wolf is straight. The wolf has much the air of the house dog (matin); but, unlike that animal, the wolf leads a rather solitary life in the great forests, reuniting in troops only when pressed with hunger. The wolf is agile, adroit, strong, and well adapted for the pursuit, attack, and conquest of his prey; nevertheless he is naturally slow and cowardly, unless pressed by hunger; he then attacks the domestic animals under man's protection; women and children, and man himself, do not then escape his ferocity.

The Chacal, the Loup doré, inhabiting the warm countries of Asia and Africa, more resemble in its habits the domestic dog than the wolf: it may be tamed.

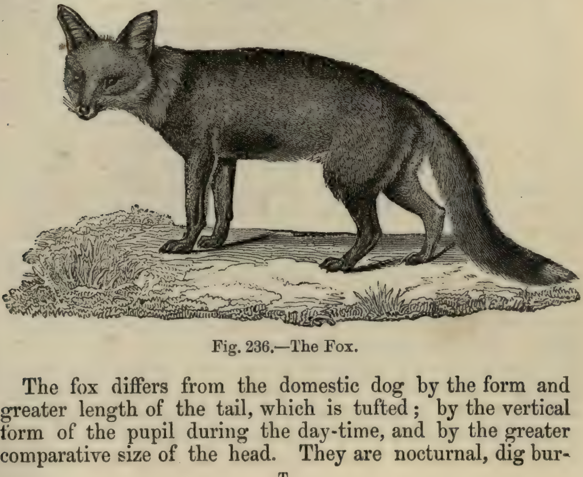

Fig. 236.—The Fox.

The fox differs from the domestic dog by the form and greater length of the tail, which is tufted; by the vertical form of the pupil during the day-time, and by the greater comparative size of the head. They are nocturnal, dig burrows under ground, have a fœtid odour, and attack only small animals. Species of the fox are to be found in all parts of the world. Those of cold countries give a fur which is much sought after.

[Notwithstanding the general resemblance of the fox and domestic dog, a resemblance extending even to the structure of the interior and the skeleton, they are yet so distinct from each other as to entitle them to be placed in different genera. Recent experiments seem to prove that they do not breed with each other, so that they have in reality no consanguinity. The knowledge of this unexpected fact we owe to direct experiment, and it is doubtful if science could ever have enabled the naturalist or anatomist to have made the discovery. The bearing of this fact on future palæontological discoveries is extremely important. A fossil skeleton might be found strictly resembling that of the fox, the hasty theorist would declare it to have been a fox, and that therefore the present geological era must have been of vast duration; another would pronounce it to have been a dog, whereas in all probability it was neither one nor the other, but the remains of an animal having no place in the present order of things. All these errors originate in the unhappy attempts of modern geologists to *restore*, as they call it, the extinct animals.—R. K.]

All the carnivora of which we have spoken, as well as many others—the genette and civet, for example—walk on the ball of the toes, the tarsus being raised. Hence the name of digitigrades; and to this they owe their upright walk and rapidity. Bears and badgers, in walking, place the entire sole of the foot on the ground; hence they are called *plantigrades*. Their movements are slow, and they lead a nocturnal life.

Bears are large, heavy animals, thick and short. The tail is short, the limbs thick; but they are animals of great strength and sagacity. The form of their extremities enables them to climb trees very readily, and to sit erect on their hind quarters. Some swim well, a quality they perhaps owe to the fat with which their bodies abound. Of all the carnivora, they are those least restricted to an animal diet; in fact, they are omnivorous, for which, indeed, the character of their teeth, almost all tuberculated, evidently adapts them; such teeth being more fitted to bruise roots and grains than to tear the flesh of animals. Vegetable food is their regular diet, and they prefer honey, of which they rob the bees, being well protected from their stings by the roughness of their hides. The greater number of the bears live in the forests, but one species frequents the shores of the Polar seas. The former live in caverns or burrows dug by themselves, their strong claws enabling them to do this. In extremely cold weather they pass the time in a profound lethargy.

§ 415. The order called amphibia is formed of two genera, the seal and walrus. In these animals, also carnivorous, the feet are not adapted for walking, but for swimming: they pass the greater part of their lives in the water.

[If my memory serve, my esteemed friend, De Blainville, placed in a distinct class certain animals truly amphibious, as the siren, proteus, axolotl, &c. Seals, otters, &c., are not strictly amphibious.—R. K.]

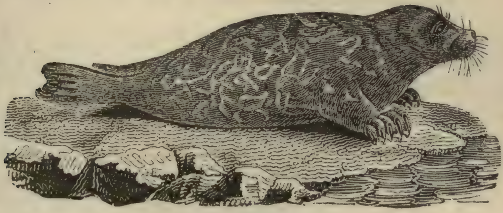

Fig. 237.—The Seal.

§ 416. The order of cheiroptera is closely united to the quadrumana, but have the pectoral extremities organized for flight by means of a large fold of integument, extending from the flank and tail to the extremity of the fingers (Fig. 238, 239). The brain also is much less developed than in the preceding groups. The dental system is still composed of incisives, canine and molar teeth. Of the class some are frugivorous, with molars resembling the quadrumana; others insectivorous, and in these the teeth are formed as in the following class. The bats are the principal representatives of the group.

§ 417. The insectivora do not differ from the other unguiculated mammals, expecting in this, that the molar teeth are evidently constructed for the crushing of insects, on which they live. They are in fact rough, with conical points (Fig. 22), which adapts them for this purpose. Their brain rather resembles that of the cheiroptera in having no convolutions, than what we find in the bimana, quadrumana, carnivora, and amphibia. The greater number make use of burrows, and hybernate. We cite, as examples of the group, the mole

(Fig. 214), the hedgehog, the desman (Fig. 209), and the shrew mouse, or musaraigne (Fig. 240).

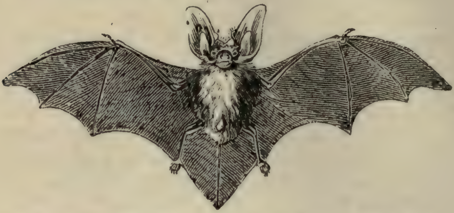

Fig. 238.—Chauve-Souris Oreillard; Large-eared Bat.

The hedgehog has the body covered with spines or quills instead of hair, and the skin of the back is provided with a large oval muscle, so that the animal can roll itself into a ball, thus presenting nothing but spines for the enemy to attack. They live in the woods, and lie concealed during the day between the roots of old trees. They are common in France.

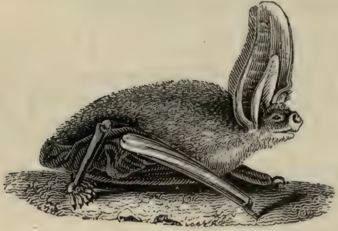

Fig. 239.—Oreillard; Large-eared Bat (walking on the ground).

The shrew mouse is a small animal, at first sight resembling a mouse. The body is covered with hairs, and on each flank is a small band of stiff hairs, between which is secreted and exudes an odorous humour. They burrow under ground, and live on insects and worms. It is a popular error to accuse them of giving rise to a disease in horses and mules by their bite.

Moles are animals essentially subterranean and burrowing. The body is thick and short; their muzzle is elongated, and terminated by a moveable snout, adapted to burrow; and their anterior limbs, though short, are extremely strong and broad, turned outwards, and terminated by strong claws admirably adapted to dig (Fig. 214). By means of these instruments, moles dig, with great rapidity and admirable instinct, long galleries under ground, in which they dwell. Molehills are formed of the product of these excavations. They seldom quit their excavations, and live on insects and worms. Destined to live in profound darkness, their eyes are scarcely perceptible, and there is a species of the mole which is completely blind. The mole has twenty-two teeth in each jaw, or forty-four in all. The common mole of the fields, of a fine black colour, is common throughout the fertile countries of Europe.

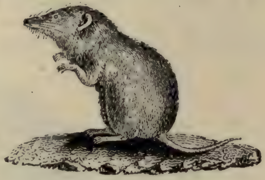

Fig. 240.—Shrew Mouse (Musaraigne).

§ 418. The order rodentia comprises the ordinary unguiculated mammals which have no canine teeth, but have strong chisel-shaped teeth in front, or incisive, and molar teeth behind. This arrangement of the teeth (Fig. 243) adapts them for gnawing very hard vegetable substances, as the bark and roots of trees, and these in fact form their principal nourishment. The brain of rodents resembles greatly that of the insectivora, and their intelligence is very confined; nevertheless, some are gifted with extraordinary instincts. Squirrels (Fig. 118), marmots, rats, hamsters (Fig. 119), the campagnol (Fig. 242), the porcupine (Fig. 195), and several other animals similarly organized, belong to the order rodentia.

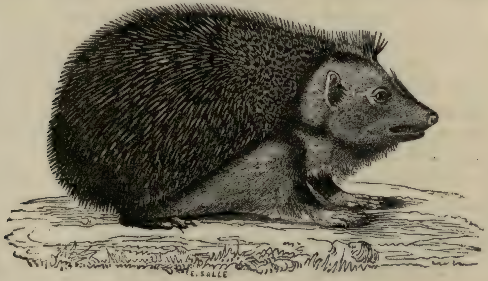

Fig. 241.—The Hedgehog.

Rodents of the genus *Mus* are characterized by some peculiarities in the disposition of the teeth, and by their long and scaly tail. They are small animals, and live especially on fruits and roots, but, pressed by hunger, they take to animal food, and will even attack and devour each other. Three species have become common in our houses: the domestic rat, the surmulot, and the mouse.

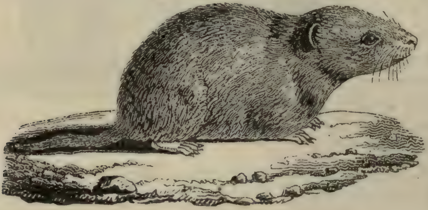

Fig. 242.—The Field Vole; Arvicola Agrestis; Campagnol.

The rat was not known to the ancients, and seems to have been imported into the Old World from America. The epoch of its introduction is unknown, but it existed in great numbers where the surmulot now abounds. This latter seems to have almost extirpated the common rat. It is now very rare in Paris, and is to be found chiefly in barns, where it lives on grains and vegetables of all sorts it finds there; but it has a decided taste for animal food, and it pursues young animals. In country-houses it is a destructive plague, by the damage it does to linen, harness, lard, and, in short, to everything eatable which falls in its way.

The surmulot is the largest of the rats: it is of a reddish-brown colour. Introduced into Europe in the eighteenth century, it has multiplied exceedingly. Brought from India to England by sea, it spread into France, and thence into Europe, America, and all the colonies. In the neighbourhood of Paris they abound in the common sewers, and dig burrows just sufficient to hold the animal.

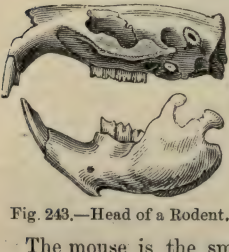

Fig. 243.—Head of a Rodent.

The mouse is the smallest of the species of rats which infest our houses; it was known to the ancients. It forms galleries for itself in the timbers of houses in which it lives, and feeds on whatever animal or vegetable substance it meets with, but prefers suet, lard, and generally fatty bodies. When inhabiting the woods in a wild state, it lives on acorns, roots, and fruits.

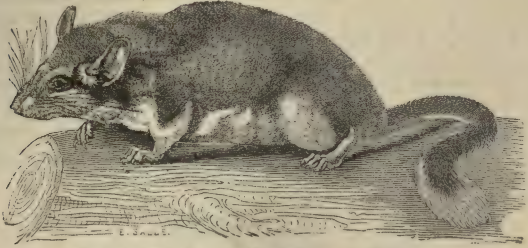

Fig. 244.—The Lerot; Mus Nitela; the Dormouse.

[The Loirs (dormice) are pretty little animals, with soft hair, velvety tail, ever tufted, with a lively look, which have a strong analogy with rats, live in or frequent (se tiennent sur les arbres) trees, supporting themselves on fruits. Like the marmots, they pass the cold season rolled up into a ball, and in a very profound lethargic sleep. They may be recognised by the number of their molar teeth, which is four in each jaw and on each side.—In the Dictionary of Fleming and Tibbins, 1841, these terms, Loir and Lerot are thus defined:—"Loir, (Lwâr) ou Liron, s. m. (sorte de petit animal qui dort, a ce qu'on pretend, tout l'hiver). Dormouse. Loir volant (potatouche ou ecureuil volant), flying squirrel. Lerat s. m. (espèce de loir) musavellanarum, the smaller dormouse.

In the *Decline and Fall of the Roman Empire*, there is a note at p. 265, vol. v. (Milman's edition), to the following effect: "The want of an English name obliges me to refer to the common name of squirrels,* the Latin *glis*, the French *loir*, a little animal who inhabits the woods and remains torpid in cold weather. (See Plin. *Hist. Natural*, viii. 82; Buffon, *Hist. Naturelle*, tom. viii. p. 158; Pennant's *Synopsis of Quadrupeds*, p. 289). The art of rearing and fattening great numbers of *glires* was practised in Roman villas as a profitable article of rural economy (Varro, *De Re Rustica*, iii. 15). The excessive demand of them for luxurious tables was increased by the foolish prohibitions of the censors; and it is reported that they are still esteemed in modern Rome, and are frequently sent as presents by the Colonna princes (see Brotier, the last edition of Pliny, tome ii. p. 458, apud Burbon. 1779)."—R. K.]

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* Is it not the Dormouse?—Milman.

The jerboas (Fig. 245) are small rodents, remarkable for the development of their hinder limbs, and this enables them to leap with great agility.

The squirrel (Fig. 118) is also a rodent, and is known by the length of the tail, furnished with hairs like a large quill or feather. They live amongst trees, on fruits and nuts, and are remarkable for their agility. There are many species in the Old and New Worlds. In France the common squirrel abounds, and retains throughout the year the colour by which it is known; but in the North it becomes, during winter, of a fine ashy-blue colour, and the fur is much sought after. In this state the fur is called *petit gris.*

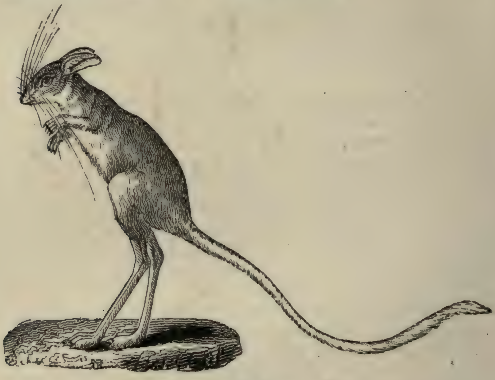

Fig. 245.—The Jerboa.

The beaver is distinguished from all other rodents by its large tail, flattened horizontally; it is of an oval form, and covered with scales. The beaver is of a good size, aquatic in its habits; their feet and tail aid them in swimming, and with their powerful cutting teeth they easily cut down all sorts of trees. They live on bark and other hard vegetable substances.

The Canadian beaver is, of all quadrupeds, that which exhibits most industry in the construction of its dwelling, at which it works in society, in the most solitary parts of North America (§ 331, p. 174).

The neighbourhood of man seems to prevent the beaver from working in society, as we find that the beavers of the Rhine are solitary, and never construct habitations like those of Canada, although they seem to belong to the same species. The beaver was formerly indigenous to many European countries, and even to Britain.

§ 419. The order of edentata (toothless animals) seems to fill up the link between the unguiculata and the ungulata, for the nails acquire a great development, and cover a large portion of the extremity of the fingers and toes; but that which characterizes them is the absence of teeth in the front of the mouth (Fig. 246).

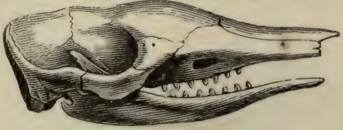

Fig. 246.—Head of the Armadillo.

The dentition is composed of canine and molar teeth only, and even these are also sometimes absent (Fig. 29); the edentata live, in fact, on soft insects, or leaves easy to gather. As examples of this group, we cite the armadillos (Fig. 247), the pangolins (Fig. 196), and the ant-eaters.

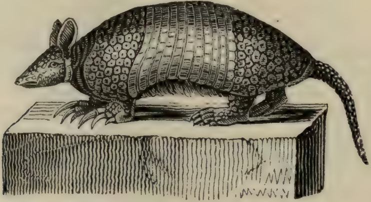

Fig. 247.—The Armadillo Cabassou; the Tatou, or Tatouay of D'Azzara.

§ 420. The order of pachydermata belongs to the division of mammals having hoofs, and is composed of all the ungulata in which the stomach is formed in the usual way, and not intended for rumination. They are remarkable for the thickness of their skins; they are all more or less herbivorous; and their brains have convolutions, as in the carnivora. Some have the nose prolonged into a proboscis, and are for this reason called proboscidians: the elephants (204) have this feature. Others are recognised by the feet terminating in a single toe, covered with a hoof; the horse, ass, and zebra offer this character, and hence the name of solipeda. Finally, the ordinary pachydermata have the feet terminated by fingers or toes, varying from two to four; the wild boar, the tapir (Fig. 208), the rhinoceros (Fig. 198), the hippopotamus (Fig. 251), belong to this class or group.

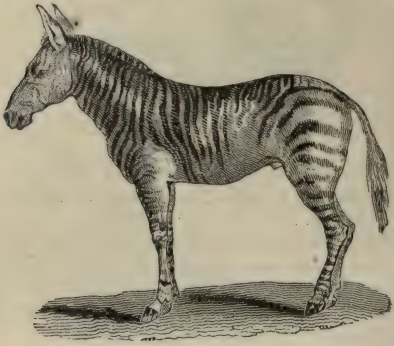

Fig. 248.—The Zebra.

The genus elephant (Fig. 204), the largest of all land animals, is of a mild and gentle nature, and hence the ease with which it may be domesticated. The great size of the head and weight of the tusks necessitate a proboscis to enable the animal to feed (page 243). By means of this singular instrument the elephant uproots trees, unties the knots of a cord, picks a lock, or uses a pen. Their sight is tolerably good, their hearing fine, and their sense of smell acute. Their caution is extreme, and their intelligence remarkable. They remember injuries, and are not forgetful of favours. Though of heavy gait, their speed is considerable, owing to the length of their pace. Although the elephant is the most powerful of quadrupeds, he is naturally neither cruel nor formidable. Courageous in defence, he seldom attacks. By nature he is gregarious, living in troops, varying from fifty to one hundred, and is seldom seen solitary. The oldest leads the troop, and the next in age brings up the rear.

Taken when young, they are readily trained to carry enormous weights; 2000 pounds weight is the load of the adult, and they will perform with this a march of fifteen or twenty leagues. They swim well, and live to nearly two hundred years.

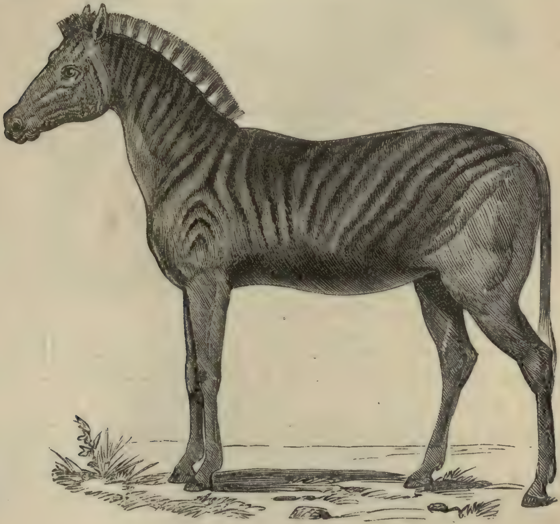

Fig. 249.*

Two species of elephants have been described,—1, the Asiatic; and 2, the African. The first is known by its elongated head, concave forehead, and comparatively small ears; four nails on the hinder toes; the molar teeth also present parallel ridges, nearly equidistant. The tusks often remain short. 2. The African species (Fig. 207), remarkable for the size of the tusks, development of the external ears, three loose nails on the hinder toes, shorter head, and convex forehead. The surface of the molar teeth (Fig. 206) when in use presents rhomboidal figures, by which it may be at once distinguished from the Indian species. The female has tusks nearly as large as the male. It is a more active and ferocious animal than the Asiatic, and is found from Senegal to the Cape of Good Hope.

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* Equus Burchellii—a species of Zebra discovered by Mr. Burchell; attempts are now being made to domesticate the Daauw.

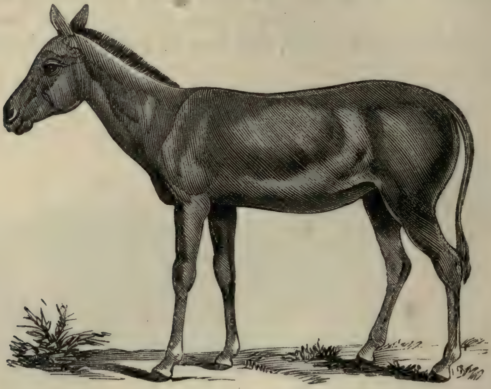

Fig. 250.*

[There is abundant evidence in history to show that the African species of elephant extended at one time from the northern slopes of the Atlas to the Cape of Good Hope. They were employed by the Carthaginians as an instrument of war in their conflicts with the Romans.—R. K.]

Ivory, properly so called, is furnished by the tusks of the elephant, recent and extinct. When cut and polished, it may be recognised by its numerous lozenge-formed curved lines.

The hippopotami have an enormous body, with very short limbs, four equal toes to each foot (the elephant has five); tail of moderate length, nostrils dilated, skin almost hairless.

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* Hemione, or Dziggetai; Equus Hemionus Pall; Native of Indostan and Upper Asia. It has been acclimatized in France.

They live on vegetables, and their habitat is the rivers of Central Africa.* Their colour is a brownish black, and they attain an enormous weight. Three or four may be seen in a line in the river, near some cataract or stream, darting at the fishes which the rapidity of the current brings near them.

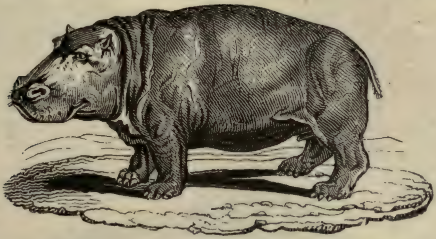

Fig. 251.—The Hippopotamus; the River Horse; Sea Cow of the Dutch.

They swim well and rapidly, and can remain a long time under water. During the night they quit the rivers, and feed on the herbage of the banks, or make their way to the fields of rice or millet, which they rapidly consume. Their march is so impetuous that they overthrow every obstacle, especially when alarmed. Their character is ferocious.

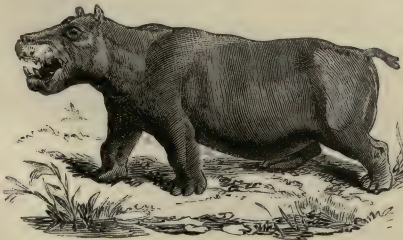

Fig. 252.—Hippopotamus.

The pig has also four toes on all the feet, but two are large and two shorter. The incisive teeth vary in number, and the tusks protrude from the mouth, curling upwards. The muzzle terminates in a truncated snout, adapted for digging up roots, on which they live, in troops, in the forests; but they show no repugnance to animal food.

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* Southern and Northern as well.—R. K.

The rhinoceros (Fig. 198) is a very large animal, with a short thick body and short limbs, remarkable for the great thickness of its hide, and for the horn or horns it carries on the nose. The horns are solid, composed of matted hairs, and supported on strong nasal bones, arched and thick; but these horns have no osseous core, and they move with the integuments. It inhabits the hottest parts of Asia and Africa, and is generally found in the elephant countries. It is ferocious and untameable, and is fond of wallowing in miry places, like the pig (Fig. 199).*

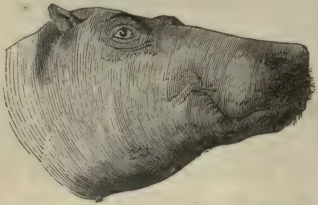

Fig. 253.—Head of a Young Hippopotamus of Southern Africa; from a drawing by Burchell.

The genus horse, comprising the horse, properly so called, the ass, zebra, and several other species, is characterized by the conformation of the feet, single toed, and covered with a hoof; by six incisives in either jaw, hollowed when young, which hollow disappears with age; by six molars on either side of each jaw, and by a space or bar between the small canine teeth found in the male and the molars, which receives the *bit*. These canine teeth are small, and peculiar to the male. The eyes of the horse are prominent, his hearing good, upper lip so large as to be used as an instrument of prehension; nostrils not much dilated; the body is covered all over with hair, and the neck provided with a mane. The tail is of moderate length, but has long hairs, especially in the domestic horse. Though strictly herbivorous, their stomach is simple, and of moderate size. His mode of life in a domestic state is so well known as to require no description.

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* The double-horned rhinoceros is peculiar to Africa, and was known to the Romans. After all traces of it were lost to the civilized world, and its very existence doubted by naturalists, it was rediscovered a few years ago by Sparrman, in Southern Africa.—R. K.

The horse, properly so called, is distinguished from the other species by the uniform colour of the coat; by the tail, furnished with hairs from its basis; by his height and more elegant form. He exists nowhere now in a wild state, for the so-called wild horses of America are merely the domestic horse abandoned by man; and although their introduction into the New World is of no earlier a date than three hundred years, they are said to be found in troops mustering ten thousand.

The horse lives to about thirty years; he ought not to be employed for saddle or draught before four or five. When aged he loses most of his valuable qualities; and hence the importance attached to the age. He is called aged when the little cavities found in the incisives have disappeared by trituration: this happens at eight years; after that he is said to have lost the mark.

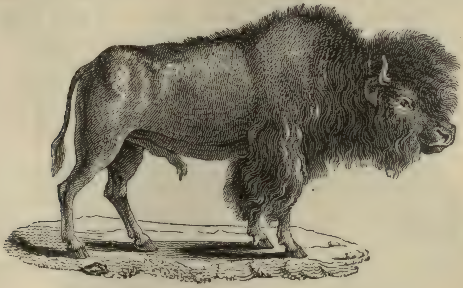

Fig. 254.—The Bison.

The ass is recognised by its height, tufted tail, dark cross on the shoulders, and long ears. More temperate and patient than the horse, he is not so strong, but still very useful as a beast of burthen. Comparatively he is both stronger and more hardy. He is choice in the water he drinks, but in nothing else, and he sleeps less than the horse. His stupid and obstinate nature seems mainly due to the bad treatment he receives; in the duration of life the ass resembles the horse.

§ 421. The order ruminants is distinguished from all the preceding groups by their complex stomachs. These animals are essentially herbivorous; they have no incisives in the upper jaw; in them the foot is divided or cloven, and it is amongst this species especially that the forehead is armed with horns. The ox, sheep (Fig. 263), goat, and stag (Fig. 264) chiefly represent the class; but the antelope, giraffe (Fig. 271), camel, lama, &c., are included in the group.

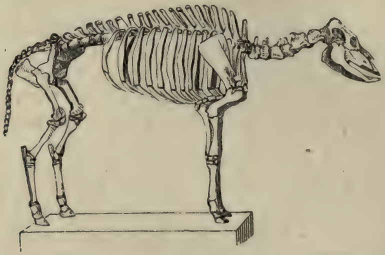
Fig. 255.—Skeleton of the White or Wild Ox of Scotland.*

The genus ox differs from other ruminants by the form of the body and the direction of the horns.

The principal species are the common ox; the aurochs, originally both European; the buffalo, the yack, peculiar to Asia; the bison and the musk ox, peculiar to Northern America.

The common ox, when young, is called a calf, the male a bull, the female a cow; its forehead is flat, longer than

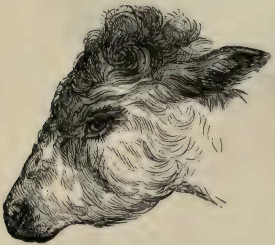
Fig. 256.—Head of Young Scotch Bull.†

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* From the drove belonging to the Duke of Hamilton.—R. K.

† Head of the Ox called Urus Scoticus, or Wild Ox of Caledon, drawn from a specimen of the breed preserved in the Forest of Cadzow, and belonging to the Duke of Hamilton. They are of a dun white colour, with black ears and hoofs. I ascertained many years ago that the purity of the breed is preserved by destroying all calves which are differently coloured.—R. K.

broad; the horns are rounded and project from the extremities of the prominent line separating the frontal from the occipital bone. There exists scarcely an animal so useful to man as the

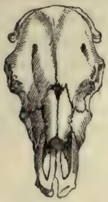

Fig. 257.*
White Ox of Scotland.

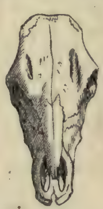

Fig. 257*a*.†
Common Ox of Scotland.

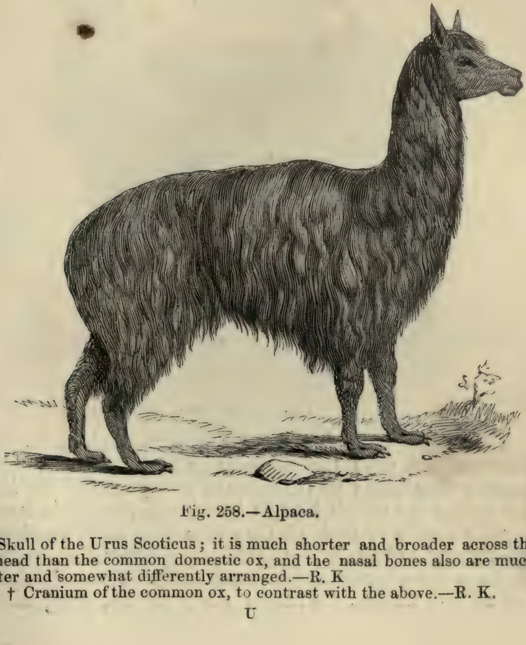

Fig. 258.—Alpaca.

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* Skull of the Urus Scoticus; it is much shorter and broader across the forehead than the common domestic ox, and the nasal bones also are much shorter and somewhat differently arranged.—R. K

† Cranium of the common ox, to contrast with the above.—R. K.

ox: on this we need not dwell. The flesh is excellent; he can be made to labour like a horse; the bones, skin, horns hair, all are of use. The fat is fine and delicate, and the, blood is used as a fertilizer, and also in the manufacture of Prussian blue; it is in use moreover as a refiner of sugar and fish oil. The intestinal membrane is employed in the arts of the gold-beater and to cover air balloons. From the milk of the cow we obtain butter, cheese, and cream; with the stomach called rennet we curdle milk. The ox is now found in every part of the world, but no doubt it belonged originally to Europe and Asia.

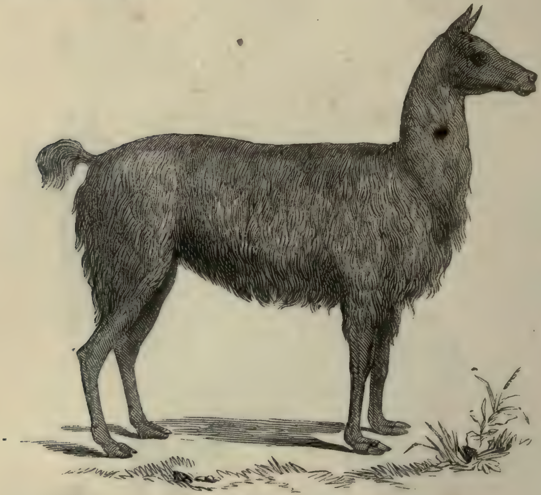

Fig. 259.—Llama.

The aurochs is the largest of European quadrupeds. It is distinguished from the domestic ox by its convex forehead, broader than long; by the point of attachment of the horns, lower than the occipital crest; by a kind of woolly hair covering the head and neck of the male; by a short beard under the throat; and finally, by having an additional pair of ribs. It is not the origin of our domestic cattle. Formerly abounding all over Europe, the race is nearly extinct, being confined to the marshy forests of Lithuania, of the Krapacks, and the Caucasus.

The buffalo, of Indian origin, but now naturalized in Italy and Greece, has the horns marked anteriorly by a longitudinal crest. The buffalo is less docile than the ox, but he is stronger and easier supported. He swims well (as does the ox), and likes to wallow in muddy waters; and he will dive ten or twelve feet, tearing up with his horns aquatic plants, which he eats while swimming.

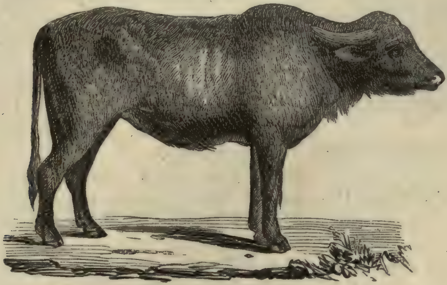

Fig. 260.—Buffalo.

[The buffalo, presumed to be of Asiatic origin (like the ox), has been long domesticated in Africa and in Italy, into which country it was introduced in 595 or 596.—R. K.

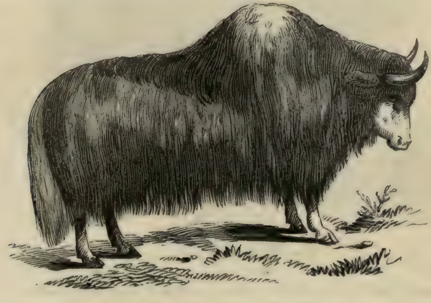

Fig. 261.—Male Yak.*

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* From Thibet; now being domesticated in France.—R. K.

The yak, also called the buffalo with a horse's tail, the grunting cow of Tartary, is a small species originally from Thibet. It has a long mane, and a tail with long hairs like the horse. It is with this tail that the standards are made which, with the Turks, serve to distinguish the superior officers.

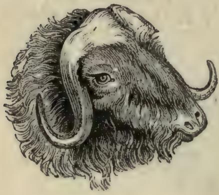

Fig. 262.—Musk Ox.

The musk ox is an inhabitant of the more northern parts of North America. It climbs over rocks like a goat. Its odour is peculiar; hence the name; and its horns are united in the middle of the forehead.

The American bison strongly resembles the aurochs, but has the limbs shorter, and differs in some other respects, as in having the hair longer.

The genus sheep (ovis) differs but little from the goat. Their horns are disposed to become spiral; they have no beard, and have the forehead convex.

A wild species, called argali, with very large horns, seems to be the original of the domestic sheep. They are found in great numbers in Kamtschatka; in all the lofty mountainous regions of Asia; in the higher ranges of those of Barbary,

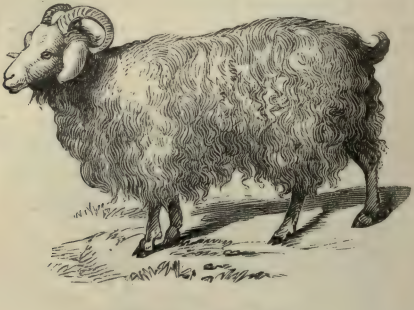

Fig. 262*a*.—Angora Goat.*

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* It is being now domesticated in France.—R. K.

Corsica, and Greece. It grows to a large size, and is very agile.

The mouflon (Fig. 263), found in Europe and Africa, differs from the argali in this, that it never attains the same size.

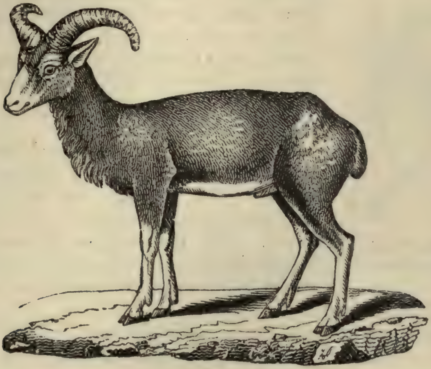

Fig. 263.—The Mouflon; Ovis Musimon. The Wild Sheep of Sardinia.

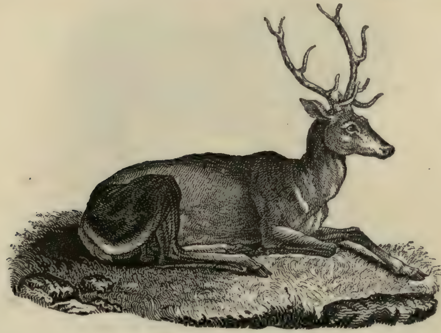

Fig. 264.—The Stag.

The female rarely has horns, and when present they are small. Varieties of the mouflon exist. Some are white, others more or less black. They live in troops.

The domestic sheep when young is called a lamb: the female is called an ewe: the male, a ram; it is too well known to require any zoological description. The variety called merino, remarkable for the fineness of its fleece, and at one time limited to Spain, has been extensively introduced into France and Germany, both as a pure breed and as crossed with others. Five hundred thousand of the pure breed exist in France. The clip takes place in the month of May.

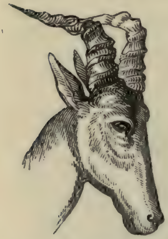
Fig. 265.—Head of Antelope Canna.*

The goat resembles the sheep as regards the horns; but it differs in the direction they take. Its chanfrein, or face and head, is concave, and it has a beard. All the species of this genus belong to Europe and Asia; they live in small troops amongst the rocks, and display astonishing agility.

The ægagre, or wild goat, seemingly the origin of all the domestic species, lives in troops in the mountains of Persia, and perhaps even amongst the Alps.

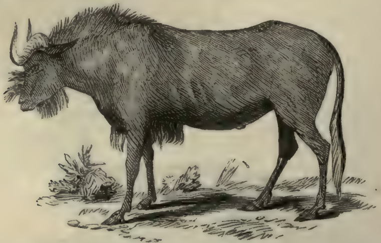
Fig. 266.—Gnu or Wildebeest of the Dutch Colonists.†

The bouquetin is another wild species inhabiting the summits of the lofty mountains of the Old World.

The domestic goat prefers rocky ground as a habitat: its milk is less apt to curdle in the stomach than that of the cow, and is thus esteemed to be of easier digestion. It is a fearless animal, dreading neither heat nor cold, storms nor rain.

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* Hartebeest of the Dutch Colonists of the Cape of Good Hope; an Antelope.

† I saw them in vast droves on the Great Bonlebok Plain, to the North of the Wenterbergen, Cape of Good Hope.—R. K.

Deer are ruminants, characterized distinctly by the shedding of their antlers. The species abound,—such as the common or fallow-deer, the red-deer, the roebuck, the reindeer, &c. They all inhabit the forests, and are remarkable for their speed and for the elegance of their forms. The antlers, generally peculiar to the male, are cast in spring.

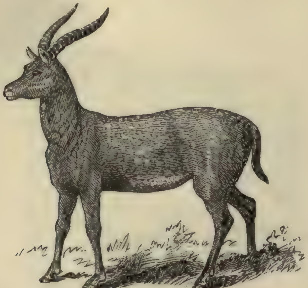

Fig. 267.—African Antelope.

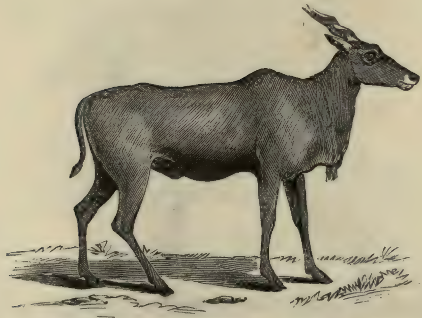

Fig. 268.—Eland of the Cape; the largest of the South African Antelopes.

The antelopes resemble deer in many respects, but are readily distinguished from them by having persistent horns, like goats and sheep. The chamois belongs to this group.

The giraffe is distinguished from all other ruminants by

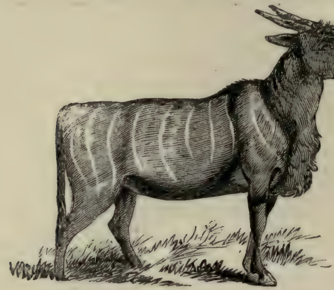

Fig. 269.—Striped Eland.*

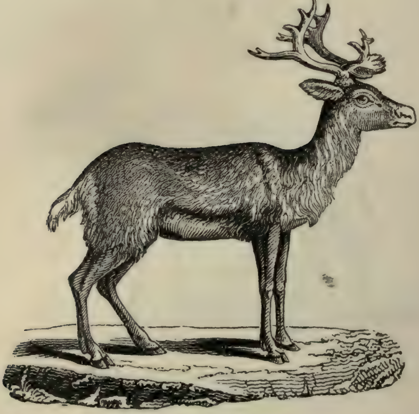

Fig. 270.—The Rein-Deer.

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* Striped Eland, discovered by Dr. Livingstone within the tropics, to the north of the Cape Colony. What is remarkable in the history of these two species or variety of the Eland is that the *young* of the Cape Eland is striped like the northern species, but the stripes disappear as the animal becomes adult.

the form of the body and the nature of its horns, which are conical, osseous, and always covered with the integuments. It measures from fifteen to seventeen feet in height, and the single species as yet known is peculiar to Africa.*

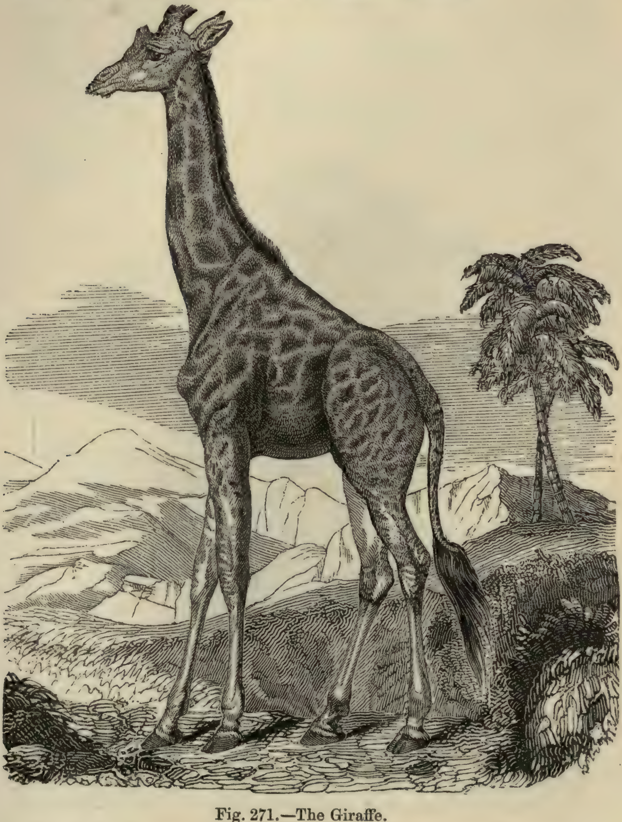

Fig. 271.—The Giraffe.

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* In Southern Africa it is never seen to the south of the Great Orange River.—R. K.

The camel is remarkable for the enormous mass of fat found on the shoulders and back, single or double. Of the camel there are two species—the Bactrian with two humps, and the Arabian or dromedary with one. Their feet are peculiar, the two toes being reunited nearly to the points by a strong sole, admirably fitted for traversing sandy deserts. Without the camel, man could with difficulty have traversed

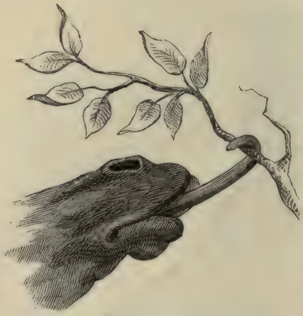

Fig. 272.—Tongue of the Camel Leopard.

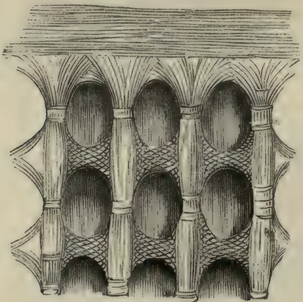

Fig. 273.—Cells of Llama's Stomach.*

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* Peculiar cells or pouches in the stomach of the Llama; they strictly resemble those which were supposed to be peculiar to the Camel.—R. K.

the deserts of Asia and Africa. It is exceedingly temperate as to the use of water, a quality which has been ascribed to the peculiar form of its stomachs; in two of these large cells exist, which either serve as reservoirs or which have the power of secreting water. In Arabia it is held to be the most valuable of animals. Of the long hair which it casts annually, the Arabs make tents and clothing; they use the milk; and as a beast of burden and of sudden flight it is invaluable.

Finally, the llama, of which there are several species, is peculiar to South America. It resembles the camel in many respects, and especially in the structure of its stomach; but it has no hump.

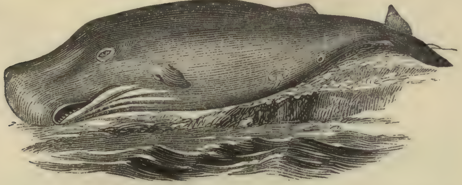

Fig. 274.—Sperm Whale.

§ 422. The fish-formed mammals comprise only a single order—that called cetacea. They are strictly aquatic, and resemble fish somewhat in their forms. In these the pelvic limbs are wanting, and the pectoral are converted into swimming paws or fins; the tail is terminated by a broad horizontal flipper composed of two flanges. The marsouins (porpoises) (Fig. 193), the dolphins, the cachalots, (sperm

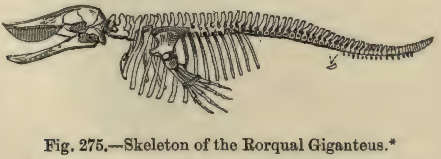

Fig. 275.—Skeleton of the Rorqual Giganteus.*

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* This specimen was dissected by myself and brother; it measured eighty feet in length. The upper jaw and cranium weighed a ton and a half; the lower jaw-bones two tons.—R. K.

whales,) and the balænæ, (whalebone whales—balænæ and rorqual,) or whales properly so called, belong to this group.

The whales are enormous cetaceans, whose head forms about a third of the length of the whole body. In the mouth there are no teeth, but numerous plates of whalebone depend at the sides from the mucous surface of the upper jaw. They are so arranged as to form towards the mouth a sieve, calculated to retain very small animals, on which indeed these huge cetaceans live. The volume of water they take into the mouth is expelled through the nostrils; hence the name of blowers and blow-holes given to their anterior or superior nostrils.† Contrary to what might be imagined, these enor-

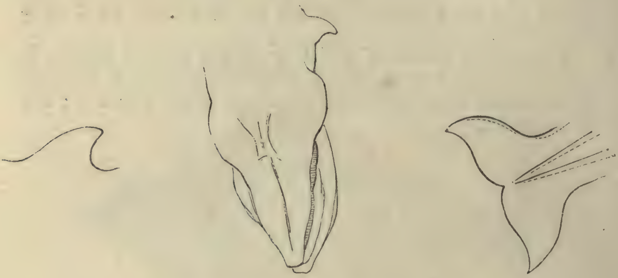

Fig. 276.—Head and Tail of Balænoptera rostrata.*

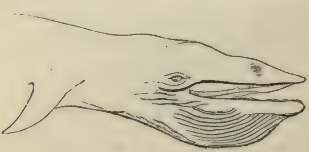

Fig. 277.‡

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* Sketches made by Mr. E. Forbes, who at that time acted as my assistant.

† It has been shown by Scoresby, myself, Beale, and a number of other observers, that the pretended *jet d'eau* is merely the vapour from its lungs. —R. K.

‡ Head of the Rorqual of Fabricius; a whalebone whale. Drawn by Edward Forbes.

mous animals live generally not on fishes, but on small mollusca, crustacea, zoophytes, and generally the lowest marine animals. They swim rapidly, and are timid and fearful; hence they are easily destroyed by the whalers.

There are several species of whalebone whales, but that which is most sought after, by reason of the length of whalebone and the abundance of blubber it possesses, is the Greenland whale, or whale of commerce; formerly perhaps abundant in the European seas, but now driven by persecution to take refuge in the Northern and Polar Seas. It has no dorsal fins.

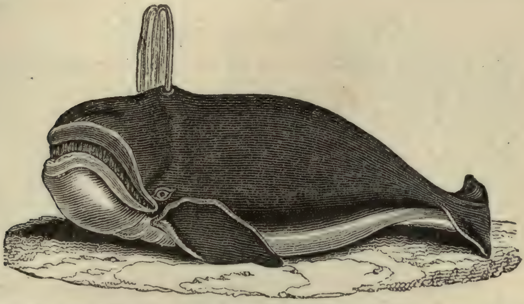

Fig. 278.—The Whale of Commerce; Balæna Mysticetus, or Greenland Whale.

The cachalot or sperm whale has teeth only in the lower jaw, and no whalebone. The enormous size and singular form of the head of the cachalot is owing to a vast collection of oil, which, when cold, becomes fixed, and forms the substance called spermaceti. It is situated in cavities occupying the upper part of the face and head. These cavities are supported laterally by largely developed upper jaw-bones, which give to the skeleton of the head a very peculiar appearance.

The whale fishing, an important branch of commerce, and in which the boldest sailors are trained, was at one time in the hands of the Basques, but now almost exclusively belongs to the English and Americans. The vessels proceed either north or south. The northern fishery has for its object the capture of the mysticetus, or Greenland whale. In the stormy seas of the North, the whaler attacks the whale with the harpoon. The blubber is found immediately beneath the integuments, and indeed may be considered as forming a portion of them. No fat exists in the interior of the whale, but the bones, especially those of the head, afford much oil.

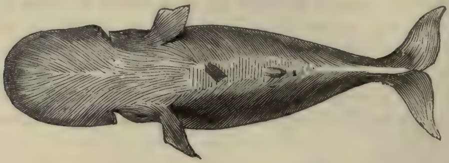

Fig. 279.—Fœtus of Greenland Whale.*

The South Sea Fishery has for its object the capture of the cachalot or sperm whale, and is carried on mostly in the Pacific and Japan Seas. The spermaceti is the object sought for.

The dolphins and the marsouins (porpoises) have the head much smaller than the true whales, and they have teeth in both jaws; they are extremely carnivorous. Lastly, there are cetacea which are herbivorous; these are the lamantins and dugong.†

[*Tabular view of the number of vertebræ in the class Cetacea.*

	Balæna Mysticetus Australis	59, Cuvier.
	Balæna Mysticetus Borealis (adult)	Unknown.
	Balæna Mysticetus Borealis (fœtus)	48, Knox.
	Rorqual Giganteus	65, Knox.
	Rorqual of Fabricius	48, Knox. 46, Hunter.
	Rorqual of the Cape	52, Cuvier.
	Rorqual of Rudolphi	54, Rudolphi.
	Cachalot	60, Cuvier.
Not Cetacea.	Dugong	56, Knox. 48, Home. 52, Cuvier.
	Manatee of America	46, Cuvier. 48, Home.

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* Drawing of the fœtus of the Mysticetus Borealis, abdominal surface, from a specimen brought from the North Seas at my request by Mr. R. Auld. It was removed from the uterus after the death of the parent.—R. K.

† The Lamantins and Dugong are certainly not Cetaceans, as I proved long ago. See *Tr. R. Soc. Edin.* 1830.—R. K.

Manatee of Senegal	Unknown.
Delphinus Delphis	67, Cuvier.
Delphinis Grisens	61, Cuvier.
Dolphin in our Museum	81, Knox.
Dolphin in Dr. Hunter's Museum, Glasgow	90, Knox.
Dolphin dissected by Mr. John Hunter, and considered by him as the D. Delphis, but by M. Cuvier as the D. Tursio	60, Hunter.
Phocæna.	66, Cuvier. 65, Knox. 51, Hunter.

N.B.—This discrepancy in the number of vertebræ in the Phocæna may be specific; but this is not likely.—R. K.]

§ 423. The division of the mammalia called didelphian, is characterized by physiological distinctions of great importance. In general the young are born prematurely, as it were, and exceedingly imperfect, and they seem, whilst in the womb, not to be nourished by a placenta, as is the case with all the monodelphs. The brain is comparatively smooth, and without a corpus callosum; and marsupial bones attached to the pelvis (Fig. 212), give a peculiar character to the skeleton.

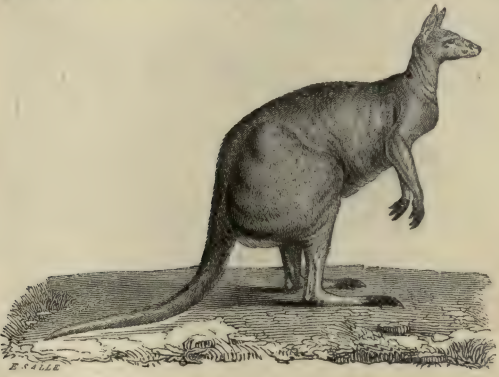

Fig. 280.—Kangaroo.

This group is composed of two orders—the *marsupial* and *monotremes*.

§ 424. The order marsupialia is chiefly characterized by the presence of a sort of pouch, destined to hold the young whilst attached to the nipple, and during the early period of their growth. A description of this pouch, with a drawing of the form of the marsupial bones, will be found in Fig. 194. The food of the marsupialia is various, some being insectivorous, others herbivorous, others carnivorous, whilst some strongly resemble the class rodents. They nearly all belong to Australia and Tasmania. The opossums (Fig. 194), the phalangers, and the kangaroos (Fig. 280), chiefly represent the group.

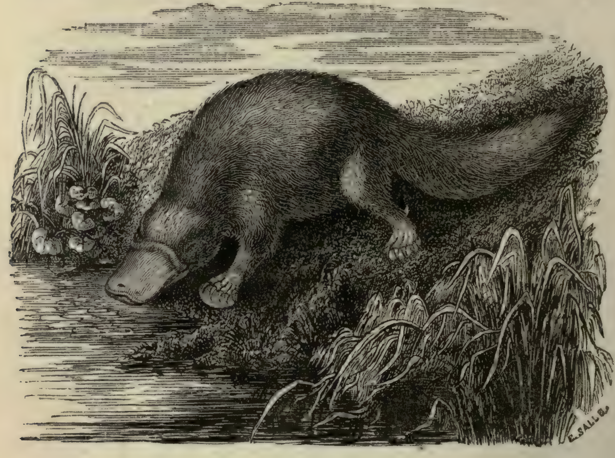

Fig. 281.—The Ornithorynchus.

§ 425. Finally, the order called *monotremes* seems to connect the mammal with the oviparous vertebrata. The intestine terminates, as in birds, in a cloaca, and the reproductive organs present many anomalies. The dental system is rudimentary, and in some a horny covering of the jaws gives to them the appearance of a duck's bill. As yet only two genera of this singular class is known; the ornithorynchus (Platypus, or duck-billed animal) (Fig. 281), and the echidna.

[There is in the ornithorynchus, on each side a femoral gland and duct leading to the spur on its heel. The secretions of this gland

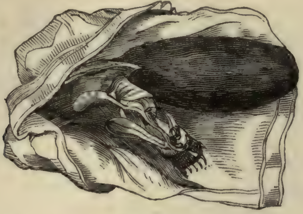

Fig. 281*a*.

were at one time supposed to be poisonous. The apparatus is of the most singular character, and was first described by me in the *Tr. Wern. Soc.*—R. K.]

THE CLASS BIRDS.

§ 426. The class birds is one of the best defined and most distinct, whether viewed with reference to the exterior or interior. Birds are oviparous vertebrate animals, with a double and complete circulation; to which may be added, that the respiration is aërien and double; which means, that instead of being confined to the lungs, as in mammals, the air penetrates throughout the body, and even into the interior of the bones; their blood is hot, as in mammals. Finally, they are covered with feathers, and their pectoral extremities have the form and character of wings.

Birds seldom attain a great size, and their bodies are light in consequence of the penetration of the air into their interior. They do not vary much in their internal structure.

§ 427. Feathers are analogous to hair, but are more complex in structure. A horny tube is first observed, pierced at its extremity, a stalk surmounting this tube. Finally, barbs, growing from the sides of the stalk; these are fringed with barbules; and these again are sometimes fringed with others still smaller.

The secreting organ of the feather is called the capsule. It would seem that so long as the feather grows, or is being developed, the capsule increases in length, and that in proportion as its base elongates, the extremity dies, and dries up so soon as it has formed the corresponding portion of this appendage. Each of these small apparatuses is composed of a cylindrical sheath, covered internally by two tunics, united by oblique septa, and of a central bulb. The substance of the feather is formed on the surface of the bulb, and to form the barbs it is moulded, as it were, into the spaces which the small septa leave between them. In the corresponding portion of the stalk, the bulb is in relation with its inferior surface, and dies; but where the stalk of the feather is tubular, the lamina of horny matter which the bulb produces turns entirely round it, and envelopes it completely. Nevertheless, the bulb, as it fulfils these functions, still dries up and dies, and thus withering successively it forms a series of membranous cones set into each other, which

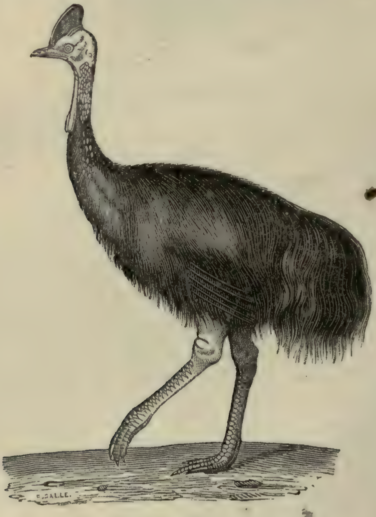

Fig. 282.—Galeated Cassowary.

fill the interior of the tube, and are called the *soul of the feather.*

The young feather is at first enclosed within the sheath of the capsule, which often projects several inches beyond the integuments, and is gradually destroyed. The feather then appears uncovered, and its barbs, at first rolled up, spread out laterally. The extremity of the quill remains embedded in the dermis, but generally may be readily detached, and at a certain period falls, to be replaced by a new feather. This renewal of the feathers is called moulting, and takes place annually, soon after the season for laying the eggs; but sometimes it occurs twice in the year. At that period the bird loses its voice, and is ill at ease.

The form of these integumentary appendages varies much; some resemble the spines of the porcupine. In the wing of the cassowary are four or five such; in others, as in the eagle and raven, the barbs are stiff, and provided with barbules, which being interlocked with those of the adjoining feather, prevents the passage of the air through them. In others, as in the tail and wings of the ostrich, the barbs and barbules are long, soft, silky, and apart. Finally, in others they resemble a kind of down, and this may be seen in certain storks, which are known by the name of *marabouts,* or pouched adjutants. Their colours vary infinitely, and often surpass in beauty the finest flowers or precious stones. The plumage of the male is generally more brilliant than that of the female; and it seldom happens that the young bird preserves the same character of plumage throughout life. They often change, for two or three years consecutively, and sometimes the adult has a summer and winter plumage quite distinct. Finally, aquatic birds have their plumage besmeared with an oily fluid, rendering them impenetrable to water, and thus preserving the skin underneath.

§ 428. The skeleton is composed of nearly the same elements as in mammals, but the form and disposition of many of the bones are different, and, *cæteris paribus,* their bones are much lighter than those of mammals, being more or less filled with air.

The head of birds (Fig. 284) is generally small; in the young bird the cranium is composed of the same number of bones as in mammals, but they unite very early together, and the sutures disappear. The face is in a great measure formed of the jaws, which are much elongated, and being chiefly employed by the bird as instruments of prehension, vary exceedingly in their character, according to the nature of the bird, the food it lives on, and the prey it attacks. The superior mandible is so articulated with the cranium as to admit of motion in the cranium, independent of the lower jaw, which never occurs in mammals; and the inferior, instead of being articulated directly with the cranium by means of condyles, is connected therewith through the intermedium of a distinct bone, called *tympanic* or *os quadratum*, generally considered to be a portion of the temporal bone (the osseous meatus), and remaining distinct throughout life. Moreover, each branch of the lower jaw is composed of two segments, and it is by a fossette that it articulates with the tympanic bone.

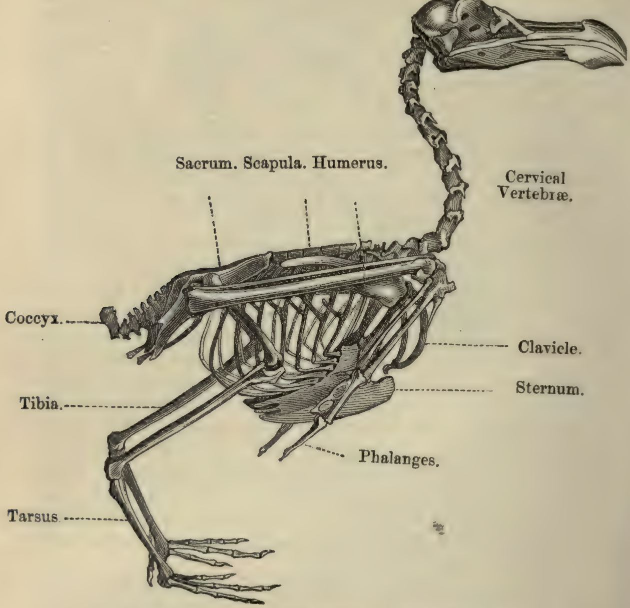
Sacrum. Scapula. Humerus.
Cervical Vertebræ.
Coccyx.
Clavicle.
Sternum.
Tibia.
Phalanges.
Tarsus

Fig. 283.—Skeleton of the Goëland. Black-headed Gull.

The mode of articulation of the head with the vertebral column admits of much more extended movements in birds than in mammals; the articulation is formed of a single condyle, a sort of semi-spherical pivot placed in the mesial line of the body, and received into a corresponding articular cavity in the atlas.

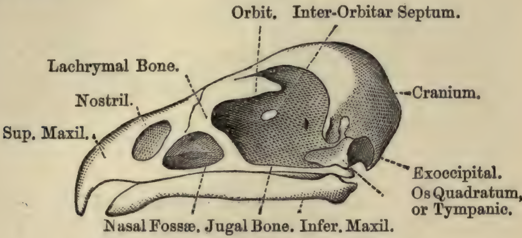

Fig. 284.—Skeleton of the head of the Eagle.

§ 429. The neck in birds is generally much longer than in mammals. The higher they are elevated on their limbs, the longer must the neck become, the jaws being the principal organs of prehension (Fig. 283); in the swan, the neck exceeds the height of the body, thus enabling it to seek its prey at considerable depths while swimming. Thus the number of cervical vertebræ varies greatly, according to the species; from twelve to fifteen is the usual number, but there may be fewer, and occasionally there are as many, or more, than twenty; they are extremely moveable on each other, and this they owe to the forms of their articular surfaces.* This arrangement is remarkable in wading birds, as in storks; numerous processes for the insertion of muscles assist in these motions.

On the other hand, in almost all birds the vertebræ of the back are nearly fixed or immovable, and this, no doubt, is to enable the wings to find in this part of the trunk a point of support. In general, they are consolidated or united into one, but in birds which do not fly, as the ostrich and cassowary

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* These articular surfaces are concave on one aspect and convex on the other (ball-and-socket). In the upper part of the neck they permit of free flexion forwards, but about the middle of the neck they admit only of flexion backwards; whilst again, towards the base of the neck, they admit only of flexion forwards.

(Fig. 161), they remain distinct, and preserve their mobility. The lumbar and sacral vertebræ unite into one; the coccygeal are small and moveable, the last generally larger than the others, and is raised into a crest. It supports the large feathers of the tail (Fig. 283).

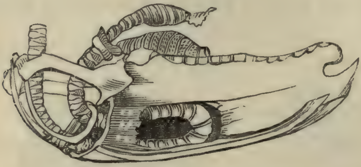

Fig. 285.—Breastbone of Swan.

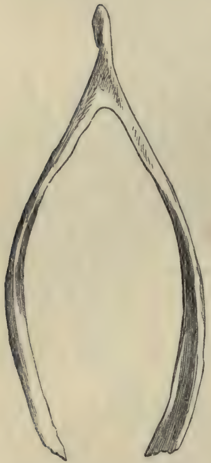

Fig. 286.—Merrythought of the Turkey.*

§ 430. The *ribs* of birds show some peculiarities tending to give solidity to the chest or thorax. The cartilage uniting the rib to the sternum is osseous in the bird, and each rib has a process, which running backwards over the other rib, so overlaps them that all the ribs support each other.

But the most remarkable part of the skeleton of the thorax is the sternum (Fig. 287), which, giving attachment to the muscles used in flight, assumes an extraordinary development, enclosing not only the thorax, but a large part of the abdomen. In the cassowary and ostrich (Fig. 161) which do not fly, the sternum has no external crest, and the wings are rudimentary; but this crest exists in other birds, and is called the keel or *brechet* (*b*, Fig. 287); by multiplying the muscular attachments favourably, it gives more force to the depressor muscles of the wings.

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* A very prevalent vulgar error is that the turkey has no *merrythought*, this being the common name given to the clavicles which rest on the sternum. Subjoined is a drawing of the *furculum*, or "merrythought" of the turkey, and of the clavicles supposed to be wanting.—R. K.

§ 431. The bones of the shoulder are in like manner favourable for the action of the wings. The scapula (*o*) is narrow and elongated, and placed in the axis of the spine; it rests on the sternum not only by the clavicles called *fourchette* or merrythought (*f*), but also by the clavicles called coracoid (*c*), so termed because they seem to be prolongations of the coracoid process in man. The clavicles called fourchette unite generally below with each other, and are attached to the crest of the sternum, and, together with the powerful coracoid clavicles offer a strong *point d'appui* for the wings to act on, and these structures are proportioned to the power of flight of the bird. Thus in some of the terrestrial parroquets of Australia these bones are reduced to an almost rudimentary state; in the cassowary and American ostrich the fourchette is represented by two small stylets; in the African ostrich and the túcan they nearly reach the sternum, but do not unite inferiorly; finally, in some owls they are united inferiorly by cartilage, whilst in the greater number of birds their bony union is complete. In many instances they form a crest at this point of union, and seek a direct support from the sternum.

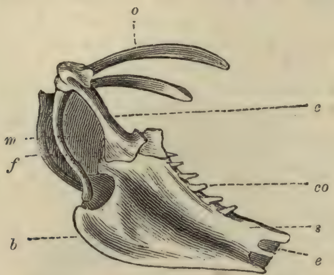

Fig. 287.—Bones of the Shoulder and Sternum, in the Bird.*

The anterior extremities of birds are employed only as wings; they must not be confounded with the so-called wings of bats, which we have already seen to be of an entirely different nature: they are formed of stiff feathers or quills, which require to be fixed only at their base, and the hand in consequence ceases to present any appearance of fingers.

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* *s*, the sternum; *e*, notch of the sternum; *co*, origin of the sternal ribs; *b*, crest; *f*, fourchette; *c*, coracoid clavicle; *o*, scapula; *t*, fibrous membrane extending from the fourchette to the sternum.

§ 432. The large quills of the wings are called *remiges*, and it is more on their length and strength than on the extent of the bones, that the power of flight depends. Each time the bird prepares for flight he raises the arm and its plumage unfolded; then he enfolds it by extending the arm, at the same time suddenly depressing it: the air which is struck forms the point of support and resistance to a downward movement; upon it he rises like a projectile, and the impulsion once given to the body is maintained and directed by the same instruments and movements: the bird would soon fall to the earth by the force of gravity, but before the speed acquired by the first effort is exhausted, a second and a third take place, continuing the living projectile in its course.

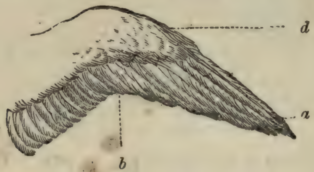

Fig. 288.—Wing of the Falcon.*

Whilst the bird is being thus suspended in the air, it becomes necessary for it to maintain its equilibrium in this position; and in order to secure this, its centre of gravity (§ 285) must be placed under the shoulders, and as low as possible; for this reason, during flight the bird carries the head well forward, the neck being on the stretch, and the body heaped together, as it were, into an oval form.

It is obvious, on the plainest mechanical principles, that, all things being equal, the faculty and power of flight will be in the ratio of the extent of the wings, these being the moving force; and in fact all birds remarkable for their power of sustaining a long and rapid flight have large wings, the opposite being the case with birds of low, slow, and short flight;

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* *a*, *remiges*, or primary quills of the hand; *b*, secondary quills, or those of the fore-arm; *d*, bastard quills, or those of the thumb.

the condor (American vulture, Vulture of the Andes) and the sea bird called *frigate*, are good examples of such powers of flight. The dwelling of the condor is on the lofty peaks of the Cordilleras, from whence he descends to the ocean at a sweep, regardless of the effect of rapid changes in the temperature and in the pressure of the atmosphere. They are said to be strong enough to carry off in their talons sheep and llamas, and when united in numbers, to attack and kill an ox.* The birds called frigates have the wings proportionally longer, and are met with in tropical seas at the distance of four hundred leagues from land.

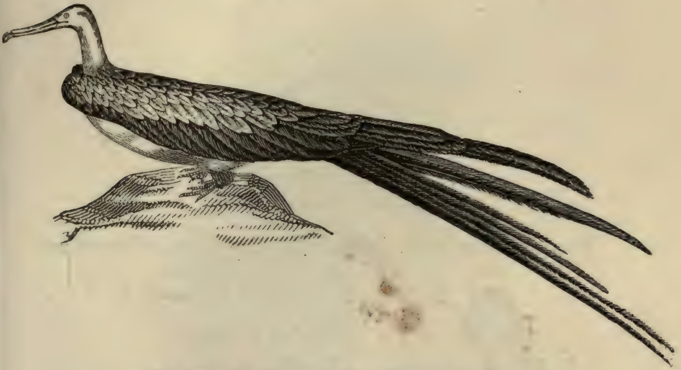

Fig. 289.—The Frigate Bird; Pelicanus Aquilus.

To rise vertically, the wings of the bird must be carried horizontally; but this is seldom the case, and from the obliquity of their position they impress on the motions of the bird an oblique ascensional movement; occasionally this obliquity is so great that, in order to rise vertically through the air the bird is obliged to fly against the wind. The relative length of the *remiges* influences the facility with which the bird rises in calm air. Birds which have the anterior *remiges* the longest and most resistant, have a more oblique flight than those which have the wings truncated at the extremities.

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* The South African Vultures, which I have seen in vast numbers in Southern Africa, have the same habits; they are a cowardly bird, notwithstanding their strength and size.—R. K.

Thus the falcons (Fig. 288), which have the wings pointed, rise only in zigzag, like a vessel tacking: whilst the hawk, eagle, and other birds of prey, called base or ignoble, whose wings are truncated at the extremities, can rise vertically through the air.

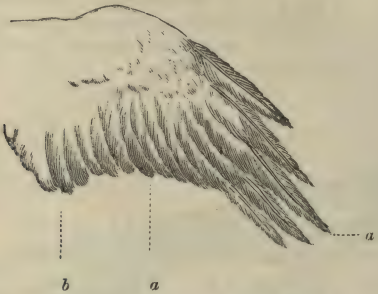

Fig. 290.—Wing of the Sparrow Hawk.*

In rising from the soil, the bird first springs or leaps from the ground by means of his feet; if these (the limbs) be too short, as in the case of the martinets, they find it difficult to make the first bound, and seek a declivity to enable them to have room for the expansion and action of their wings.

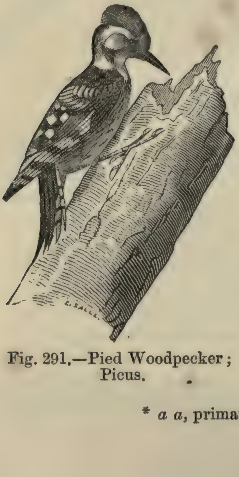

Fig. 291.—Pied Woodpecker; Picus.

Birds in their flight are assisted by the tail feathers, which seem to act as a rudder in directing their course.

§ 433. When resting on the soil, the bird is strictly a biped, and hence the necessity for a broad and large pelvis, firmly fixed to the vertebral column. The haunch bones are, in fact, extremely developed in birds, and they form, with the lumbar and sacral vertebræ, a single osseous mass (Fig. 283). In general this osseous girdle is incomplete anteriorly; the bones of the pubis do not unite with each other in front, whilst the ischiatic portions unite with the sacrum, so that the so-called notch in mammals becomes in birds a foramen or hole. The thigh-bone is short and straight, and the leg is composed, as in mammals, of a tibia, fibula, and rotula; but the fibula is united to the tibia before reaching the lower part of the leg. A single bone represents the tarsus and metatarsus; this supports or carries the toes, never more than four in number; sometimes the great toe disappears, and occasionally the one next it, thus leaving three or only two (Fig. 282). The number of the phalanges increases progressively from within outwards, from the great toe to the external or fourth, from two to five. Finally, of these four toes, three in general are directed forward, the thumb or great toe being turned backwards; but sometimes the external toe is also turned backwards, as especially in climbing birds, the parroquets, túcans, and woodpeckers, &c. (Fig. 291).

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* *a a*, primary quills; *b*, secondaries.

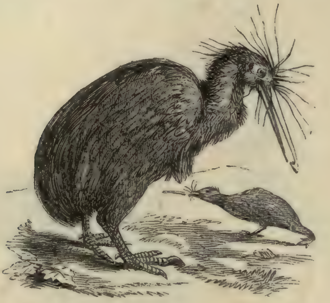


Fig. 292.—Apteryx of New Zealand.

Whilst the bird rests upon its feet on the soil, it is necessary that the centre of gravity fall within the base of sustentation; hence the utility of the extremely flexed thigh and the obliquity of the tarsus on the leg. When the foot is large and broad, and the neck is so flexible as to carry the head well backwards, the equilibrium may be thus maintained without abandoning the horizontal position (Fig. 293); but when the neck is short, the head large, and the toes of moderate length, the bird is forced to maintain an almost vertical position (Fig. 294). To maintain their equilibrium, birds place the head under the wing whilst they sleep perched on one foot (Fig. 306). The mechanism by which they stand with such ease and for such a length of time on one foot, is this: the lower extremity of the femur presents a hollow, in which is lodged, during the extension of the limb, the top of the tibia, which cannot quit this cavity but by a muscular effort. The foot once spread out, remains so, requiring no further muscular effort, and consequently giving rise to no fatigue.

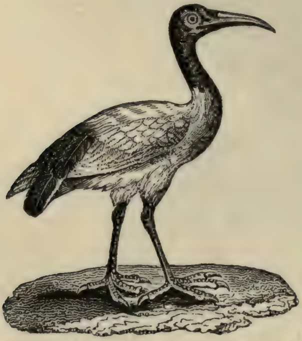


Fig. 293.—The Ibis.

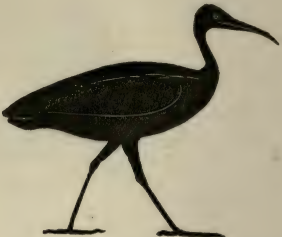


Fig. 293*a*.—Egyptian Ibis.

[Sacred Ibis of the Egyptians, as we find it represented on the walls of a temple in Upper Egypt, thus proving, according to M. Cuvier, that the Ibis we now find by the banks of the Nile is precisely the same as existed at least 4000 years ago. Together with this outline by the Coptic artist, M. Cuvier, in his great work (*Ossemens Fossiles*) gives a drawing of the Numenian Ibis of modern zoologists which he considers as the identical sacred Ibis of the Egyptians. The Ibis represented in Fig. 293 I take to be a drawing of the Numenian Ibis. I met with various species of the Ibis in Southern Africa by the banks of the Great Fish River, Bosjieman River, &c. They frequented the kraals of deserted farm steadings, on which they sought their food. The coloured natives called them "Hadada."—R. K.]

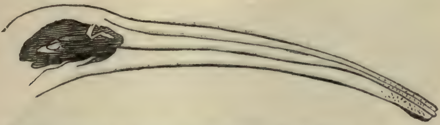


Fig. 293*b*.—Head of the Ibis; taken from a mummy, by M. Olivier.

Most birds perch, and it is easier for them to spread their wings and take flight when perched on a branch of a tree or rocky edge than when resting on the level ground. In order to perch with safety, they embrace the bough closely with their toes; and if this required an incessant muscular effort, it could not be supported for any length of time. A mechanical contrivance enables the bird to dispense with this even whilst asleep. The flexor muscles of the toes pass over the articulations of the knee and heel in such a way that, whilst they are flexed they act on the tendons of these muscles, and so flex the toes. The weight of the body assists in this movement, which enables the bird to perch without fatigue.

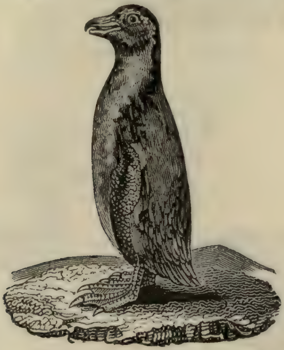


Fig. 294.—Common Penguin, also called Razor-billed Auk; Aptenodytes.

The differences which exist in the form of the feet of birds

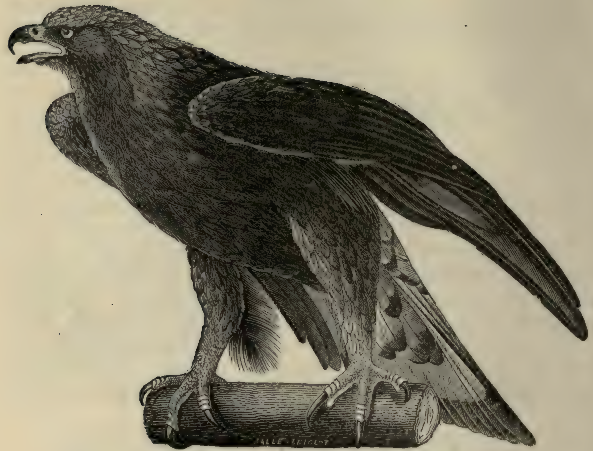
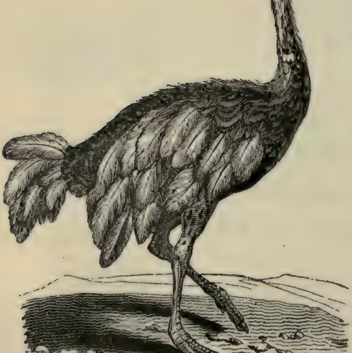


Fig. 295.—The Royal Eagle.



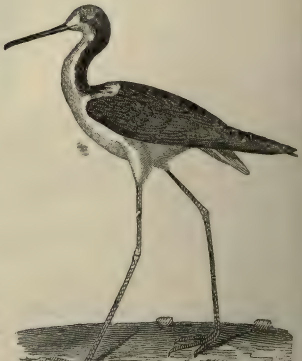


Fig. 296.—African Ostrich.

Fig. 297.—Echasse d'Europe; Stilt, or European Courser.

have a reference to the mode of life and habits of the animal. In the cassowary (Fig. 282) and ostrich (Fig. 296), birds as rapid in running as the horse, the paws are not only robust, but long, and the feet comparatively small.* In the messenger (the *falco serpentarius*, or secretary bird), which pursues serpents as his food, following them with long strides, this conformation of the foot is also observed. In the eagle (Fig. 295), falcon, vulture, &c., these organs are not merely robust, but strong, and the toes are armed with talons, large, hooked, and sharp, with which they seize, tear, destroy, and carry off their prey. Birds destined to live by the margins of rivers, and to hunt for worms and fishes in shallow waters, or by wading, have the limbs (*pattes*) slender, of great length, and naked, or without feathers as far as the knee (Fig. 297); hence their name of echassiers, or waders. Finally, in some species the feet (*pattes*, digital part of the foot) are palmated, and thus converted, by an expansion of the integuments, into a kind of oar. The laxity of this membrane permits of the full expansion of the foot, as may be seen in ducks (Fig. 300), swans, and in a great number of aquatic birds.

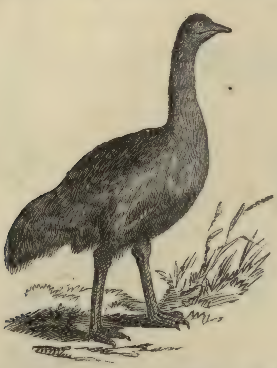


Fig. 298.—Cassowary of New Holland; the Emeu.

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* In the original it is, "Les pattes sont non seulement robustes, mais très-longues, et le pied comparativement petit." But in the word foot (pied), anatomists include always and in every animal the three regions of the toes, tarsus, and metatarsus.—R. K.

[Osseous remains of the Moa, or Dinornis.—It is now no longer doubtful that such remains, which abound in New Zealand, belonged to a gigantic bird called Moa by the natives, and Dinornis by zoologists. It is even conjectured that living specimens existed in New Zealand not long ago. In this case the bird forms, as it were, a link between the now living world and the past.

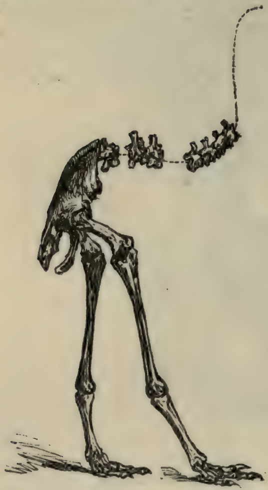

Fig. 299.—Skeleton of Dinornis.

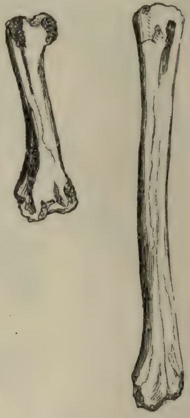

Fig. 299*a*.

In respect of the bones (Fig. 299*a*) represented in the engraving, they were discovered by my esteemed friend, John Stevenson, Esq., formerly of Auckland, in a marsh or swamp in the Middle Island, not far from Canterbury, at a depth of three or four feet from the surface. On being brought to this country, they were presented to the Geological Museum, in Jermyn-street, by the publisher of this work. Mr. Stevenson informs us that numerous similar specimens lay around.

On a careful examination of these remains I found them to be the right femur and the left tibia of a gigantic moa, whose height I have endeavoured to estimate, and to compare with that in the Museum of the College of Surgeons, with the same bones in the ostrich and emeu. The specimens are incomplete, being mutilated at their extremities.

	Inch.		Inch.
Moa, right femur.			
(Fig. 299*a*) measures	$18\frac{1}{2}$;	when complete	19
Length of the shaft	$9\frac{2}{8}$		
Around the condyles	$20\frac{4}{8}$		
Around the upper part of the bone	$28\frac{4}{8}$		
Moa, left tibia.			
Length of the fragment	36		
Probable actual length when entire	40		
Circumference around the condyles	21		
Circumference of the shaft	$7\frac{1}{2}$		

Comparative measurements, showing that this is probably the tallest bird ever brought to Europe.

Femur, length in the	Emu	9
	Ostrich	11
	Dinornis giganteus of the museum	16
	Stevenson specimen	19
Tibia, length in the	Emu	16
	Ostrich	18
	Dinornis of the museum	35
	Stevenson moa	40
Metatarsus, length of, in the	Emu	15
	Ostrich	16
	Dinornis of the museum	$18\frac{6}{8}$
	Stevenson moa	21·2

The height of the Dinornis of the museum	10ft.	6in.
Height of the Stevenson moa	12	0

It is conjectured that birds of a still greater height once existed in Madagascar.—R. K.]

§ 434. The tactile sensibility is but little developed in birds, and the form of their wings and feet is also unfavourable for its exercise. The taste is more or less obtuse, and their cartilaginous tongue, without nervous papillæ, seems ill-adapted for taste (Fig. 313). They seem to swallow their food without tasting it. The sense of smell appears stronger, but yet not much developed. The nasal fossæ are hollowed out of the base of the upper mandible (Fig. 284), without communicating with the sinuses. They have a very vascular pituitary membrane, and three cartilaginous laminæ (*cornets*) rolled on themselves, resembling the turbinated bones of mammals. These laminæ seem to be better developed in birds of prey than in others, leading one to suppose that the sense of smell is acute in this class of birds; and this has been asserted, but experiments and observations of recent zoologists tend to prove that even in these the prey is detected by the sight, and not by the smell.* The apparatus of hearing is simpler than in mammals. The external ear (figured part of the ear) is wanting, and the apparatus is reduced to an external tube, a tympanic cavity, and internal ear.† But the organ of sight seems to be more perfect than in mammals. The eyes are larger proportionally, and new parts exist. The retina is thick, and connected by means of a fold passing from the choroid to the capsule of the lens. It has been called *pecten*, and by some is thought to be a dependence of the retina. The pupil is always round, the cornea large, and the sclerotic

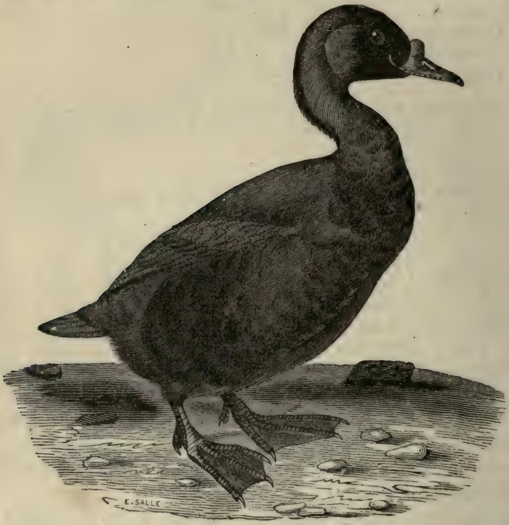

Fig. 300.—Scoter Duck; Black Duck.

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* As early as 1817, I ascertained, by direct observation, that the South African vulture is solely guided by sight in discovering his prey.—R. K.

† The *ossicula auditus* are also reduced in number, and much modified.—R. K.

furnished with osseous plates anteriorly, whose form varies with the genus and species. Lachrymal glands always exist, and besides the horizontal eyelids, they have a third, vertical, moveable, and elastic, which can be drawn completely over the surface of the eye.

Birds are well known to have a piercing and most distinct vision at all distances, that is to say, the most complete adaptation of sight. On what this depends is not clearly known, some ascribing it to the mobility of the osseous plates and to the varying form of the lens in this class of animals.*

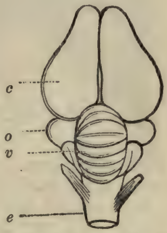

Fig. 301.—Brain of the Ostrich.

The nervous system presents the following peculiarities. The encephalon is less developed than in mammals, but the cerebral hemispheres (Fig. 301) still maintain their superiority over the other parts. The great commissure, called *corpus callosum*, is wanting, and there are no cerebral convolutions. The optic lobes, or thalami (*o*), which in mammals are small, and concealed by the overlapping of the hemispheres, are here exposed and visible without dissection. They are proportionally much larger, and instead of being solid, are hollow, like the cerebral lobes. The cerebellum (*v*) is grooved transversely by parallel and converging lines; it is almost wholly formed by the median portion; this in mammals is small compared with the hemispheres or lateral portions, which remain rudimentary, as it were, in birds, especially in bad flyers. The annular protuberance, or pons of Varolius, is wanting in birds, as well as in reptiles and fishes. Finally, the medulla spinalis (*e*) is generally very long, and has two swellings in its course, corresponding to the going off of the nerves of the wings and limbs or feet. The former is the stronger in birds of powerful flight, and *vice versâ.*

§ 435. The food of birds is very varied: grains, insects, fishes, flesh, fresh or putrid. They use the feet sometimes as instruments of prehension, but the bill is always the principal organ employed for this purpose; thus its nature varies with the food, and it becomes an important character in classification. A horny covering, solid, and more or less hard, covers the osseous bill externally, converting it into a sort of cutting and tearing instrument; but the bird never has any true teeth: hence there is no mastication, properly so called. In birds which live on flesh and tear their prey—the falcons (Fig. 303), the eagles (Fig. 295), and the vultures (Fig. 305)—the upper mandible is short, strong, hooked, and terminated by a sharp point; it is occasionally serrated, and the more or less sanguinary character of the bird may be judged of by these structures. Thus the falcon (Fig. 303), which has all these characters of the bill in the highest perfection, is the boldest of all birds of prey; whilst the kite and vulture, in which the bill is softer, less hooked, and not serrated, are cowardly; the vulture chiefly living on dead or dying animals.

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* The highly-developed annulus albus seems connected with this adaptive power.—See *Trans. R. S. of Edin.*, 1827.—R. K.

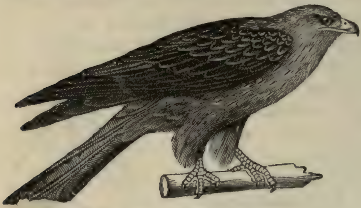

Fig. 302.—The Kite.

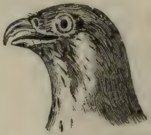

Fig. 303.—The Falcon.

Sea birds which live on fish have the bill long and hooked (Fig. 304), but much longer and softer than in the true birds of prey already spoken of. In others, which search for small fishes and reptiles which may be easily swallowed, the bill becomes still more elongated, resembling a pair of pincers. Such we find in the kingfishers (Fig. 310) and the *cigogne à sac* (adjutant), (Fig. 306). Birds which live on insects (insectivorous), worms, grains, and fruits, have nothing of the kind. In the first, the bill is very slender, and but slightly curved, or even straight, and much elongated (Fig. 307); but if they take small insects on the wing, then their bill is short and broad and widely cleft, as in swallows, goatsuckers (Fig. 308), &c. The granivorous have the bill short,

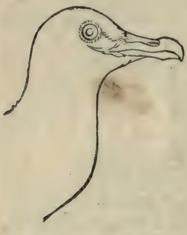

Fig. 304.—The Fulmar Petrel.

thick, arched above, or conical, and generally straight (Fig. 309). The pelicans present a remarkable modification of the bill; between the two branches of the lower jaw there is a wide cutaneous expansion or bag, in which they store their food (fishes), to disgorge it afterwards, and to feed on it at their leisure.

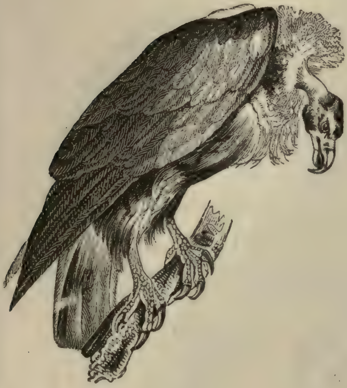

Fig. 305.—The Griffon Vulture. (Vultur fulvus).

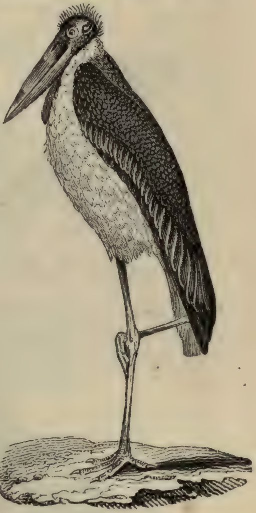

Fig. 306.—Pouched Crane, or Adjutant-bird.

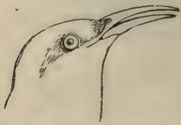

Fig. 307.—Bee-Catcher; Merops.

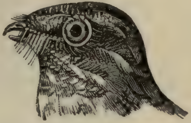

Fig. 308.—Goat-sucker. (Caprimulgus.)

But some birds present singularities in the form of the bill, the uses of which are not understood. Such for example is the bill of the rhinoceros hornbill, or calao (Fig. 312).

§ 436. The tongue in some birds becomes an instrument of prehension, and is modified accordingly. The lingual bones (*h*, Fig. 313) are prolonged backwards behind the head, and these prolongations give attachment to muscles (*m*), found anteriorly to the lower jaw. When these muscles contract, they pull forward the hyoid or lingual bones, and these push the tongue out of the mouth to a considerable distance. This structure is most remarkable in the woodpecker, and in others which dart the tongue rapidly at insects (Fig. 314). In the

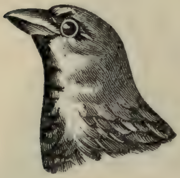

Fig. 309.—The Sparrow.

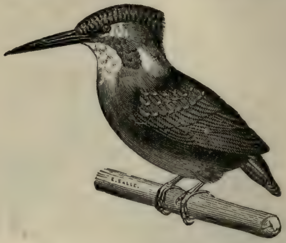

Fig. 310.—Kingfisher.

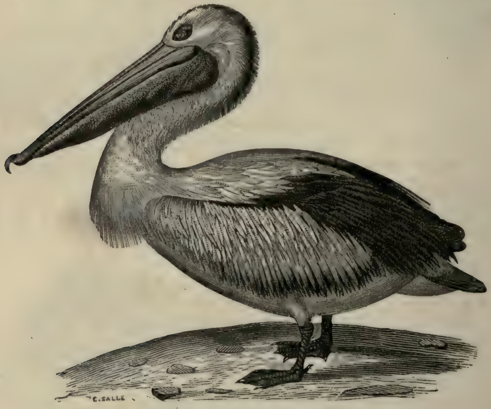

Fig. 311.—The Pelican.

parrot, which to a certain degree masticates its food, the tongue is thick and fleshy; in birds of prey it is still somewhat large and soft; in most of the granivora (Fig. 313), it is dry, triangular, and rough towards its base, with small cartilaginous points; finally, in certain insectivora its extremity is armed with hooks, and serrated or notched.

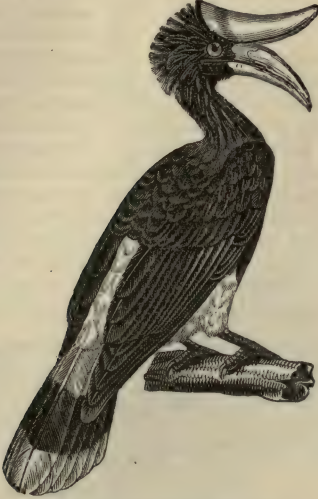

Fig. 312.—Rhinoceros Hornbill.

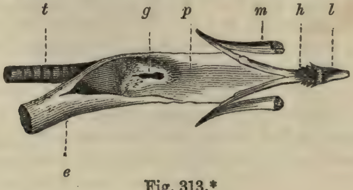

Fig. 313.*

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* Tongue, glottis, &c.; *l*, the tongue; *h*, hyoid bones; *m*, muscles of the hyoid; *p*, pharynx; *g*, glottis; *t*, trachea; *e*, gullet.

The salivary glands are placed under the tongue, and consist of small masses of little rounded follicles. The saliva is generally thick and sometimes gluish.

§ 437. There is no velum palati between the mouth and the pharynx. The gullet (Fig. 315), towards the lower part of the neck, communicates with an enlarged pouch called the crop, the walls of which are membranous. In this cavity, which varies much in different birds, the food remains for a time. The crop is most developed in granivorous birds; it is also found in birds of prey, but it is wanting in the ostrich and in most piscivorous birds. Below this enlargement the gullet contracts, but soon enlarges to form a second dilatation, called the ventriculus succenturiatus, on the inner surface of which numerous pores may be seen, leading to the follicles which secrete a gastric juice. This second stomach is generally small, but it is larger when the crop is wanting. Finally, this second stomach leads inferiorly into a third, called the gizzard, in which the chymification seems to be finished. This varies in capacity and structure. In flesh-eating birds, the gizzard is thin and membranous; but in the granivora it is powerfully muscular, and its inner surface is protected by an epidermis almost cartilaginous. Its strength is immense. In the ostrich, the hardest substances are acted on by it, and it seems to perform the office of a masticatory apparatus.

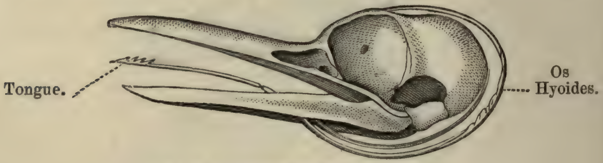

Fig. 314.—Head of the Woodpecker.

The intestine following these stomachs is much shorter than in mammals, but is composed also of two portions. The first, after forming the first turn, winds in various directions; the second differs but little from the first, and is smooth externally, but is in general easily distinguished from the first by two *cæca*, or elongated *cul de sacs*, which exist at its commencement. These appendages are very small or absent in birds of prey, but are large in granivorous birds.

The liver is very large, and fills a great part of the thorax as well as of the abdomen; these two cavities not being distinct as in mammals, the diaphragm is rudimentary. This gland, the liver, is divided into two lobes, nearly equal, and gives origin to two hepatic canals, which, after uniting, enter the

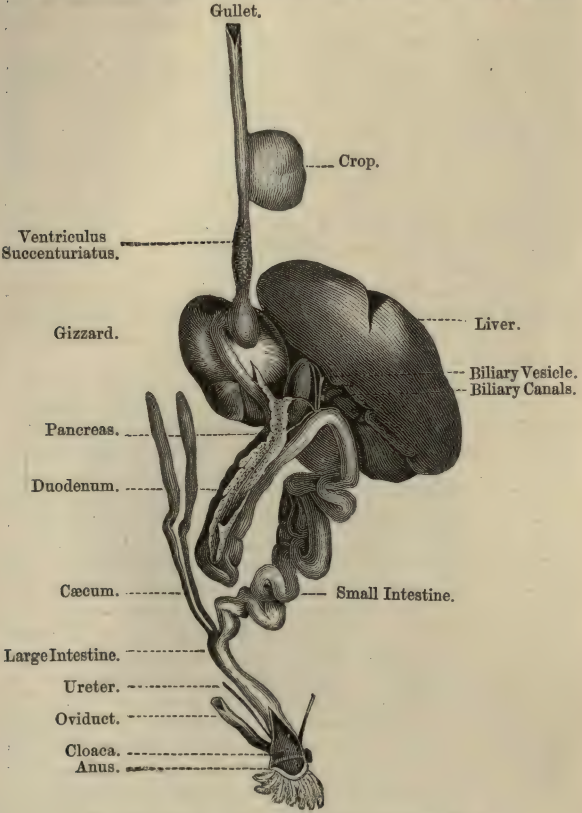
Gullet.
Crop.
Ventriculus Succenturiatus.
Gizzard.
Liver.
Biliary Vesicle.
Biliary Canals.
Pancreas.
Duodenum.
Cæcum.
Small Intestine.
Large Intestine.
Ureter.
Oviduct.
Cloaca.
Anus.

Fig. 315.—Digestive Apparatus of the Common Fowl.

intestine. Finally, a gall-bladder is almost always present, which receives from the liver a portion of bile, and pours it into the intestine by a distinct canal. The pancreas is enclosed in the first loop of the small intestine; it is long, narrow, and more or less divided.

The spleen is small; the kidneys are large and irregular in form. They are lodged behind the peritoneum, in little hollows along the upper wall of the pelvis, and, unlike the organ in mammals, they have no distinct cortical substance. The ureters, as well as the oviducts, terminate near the anus, in a dilated part of the intestine called *cloaca* (Fig. 315); there exists no urinary bladder, and the urine is voided with the excrements. The urine is composed almost wholly of uric acid, which is not very soluble, and when dried forms a whitish mass.

§ 438. The nutrient products of digestion leave the intestine by lymphatic vessels, which terminate in two thoracic ducts; these ducts open into the jugular veins an each side of the base of the neck.

§ 439. The blood of birds is richer in globules than that of mammals, and these corpuscles, instead of being globular, are elliptic (Fig. 37). The circulation in birds is complete, as in mammals, and the anatomical arrangements are the same (Fig. 47). But the walls of the left ventricle are much thicker, the auricles have no well marked appendages, and the right ventricle does not extend to the apex of the heart. These latter differences are unimportant physiologically. The aorta at its commencement divides into three large branches (Fig. 316), of which the first two convey the blood to the head and neck, wings, and muscles of the chest; whilst the third, curving downwards around the right bronchus, becomes the descending aorta. There exist also some other peculiarities in the mode of distribution of the arteries, such as the formation of plexuses in various parts of the body. The venous system terminates in the right auricle by three large trunks, of which one represents the inferior cava, and the two others the subclavian veins of mammals, which in birds enter the auricle without uniting to form a common trunk.

§ 440. The respiratory apparatus presents modifications more remarkable than those of the circulation. The lungs communicate with large membranous cells spread throughout the body, and extending even to the skeleton. Thus the venous blood in the walls of many organs becomes exposed to the

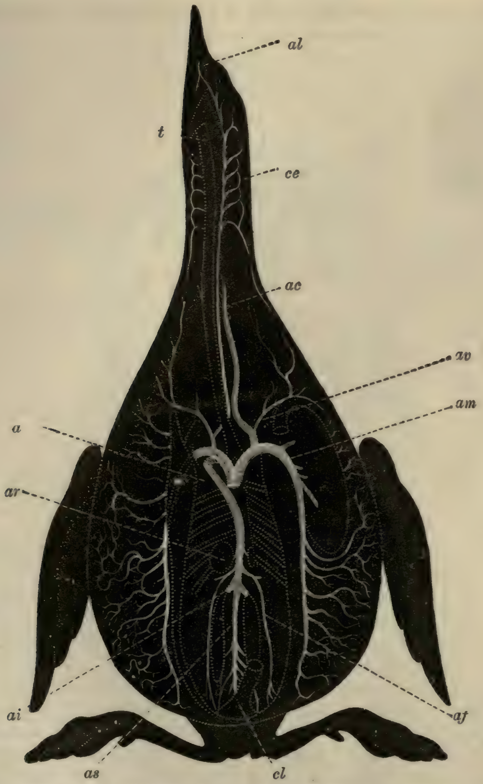

Fig. 316.—Arterial System of a Bird.* The Grebe, Colymbus—a Diver.

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* Arteries of the Grebe: *a*, aorta; *am*, one of its large branches: it gives off the carotid (*ac*) and subclavian, is ultimately distributed to the muscles of the chest, and corresponds to the mammary arteries of mammals; *av*, one of the branches of the vertebral artery supplying the muscles of the shoulder; *ce*, arterial loops formed by the branches of the external carotid; *al*, lingual artery; *t*, trachea or windpipe; *ar*, renal arteries; *ai*, ischiatic artery, proceeding to the lower extremities; *as*, sacral artery, forming a continuation of the aorta, and giving origin to the inferior mesenteric artery, &c.; *cl*, the cloaca.

action of the oxygen contained in these cells, as well as whilst traversing the pulmonary capillaries.

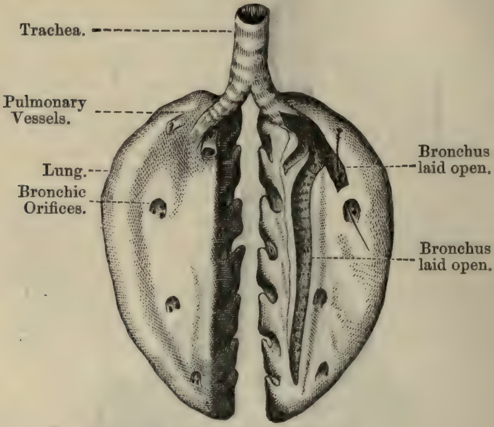

Fig. 317.—Lungs of a Bird.

The lungs are not divided into lobes, neither do they fill the cavity of the thorax. They are, as it were, fixed to the ribs, and present on their inferior surface several orifices (Fig. 317) belonging to the bronchial tubes, which traverse them through and through, and thus convey the air into the various air cells spread throughout the body. These membranous cavities communicate with each other.

The extension of these cells, and consequently of the air they contain, bears a ratio to the powers of flight of the bird: in the eagle they are found in all the bones; in the penguins the air is excluded from all, or from nearly all, the bones. The air is generally found to extend most into the bones chiefly used for locomotion, as the femur of the ostrich.

We have already alluded to the power which birds have of resisting cold, due to the development of the respiratory function, and to a higher temperature than is found in other animals.

§ 441. As in mammals, the organ of voice is a dependence of the respiratory system. The upper larynx is of a very simple structure, and has but little to do with the formation of sounds. Its orifice has the form of a fissure (*g*, Fig. 313); but towards the lower extremity of the trachea is the true larynx, most remarkable, as might be expected, in singing birds. This complex apparatus will be best understood by a reference to Figs. 318 and 319. It may be compared to a kind of osseous drum, the interior of which is divided inferiorly by a traversing beam of the same nature, surmounted by a thin semilunar membrane (*c*, Fig. 319). This drum communicates inferiorly with two apertures of the glottis (*rimæ glottidis*), formed by the termination of the bronchi, and each provided with two lips, or vocal cords; finally, muscles whose numbers vary with the species, extend between the different rings of which these parts are composed, and move them so as to stretch more or less strongly the membranes they support. In birds which do not modulate the sounds in a complex way, the membranous septum is wanting; in birds which do not sing, there are no muscles proper to the inferior

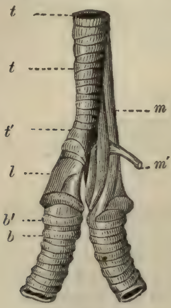

Fig. 318.*

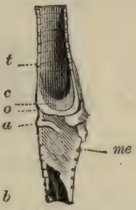

Fig. 319.†

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* Inferior larynx of the rook: *t*, trachea; *t'*, drum formed by the lower end of the trachea; *l*, middle ossiculum of the trachea; *b'*, first ring of the bronchi, separated from the third ossiculum of the larynx by a membranous space; *b*, bronchi; *m*, proper muscles of the larynx; these muscles have been removed on the opposite side; *m'*, depressor muscles of the trachea.

† Vertical section of the larynx:—*t*, inferior portion of the trachea divided as regards the half; *c*, semilunar membrane, situated above the point of reunion of the two glottides, and fixed to the osseous cross-beam (*o*); *a*, little rim formed by the internal lip of the right glottis; *me*, inner surface of the right bronchus, formed by a tympaniform membrane; *b*, portion of the cavity of the right bronchus, exposed by a section of a part of this membrane.

larynx, and the condition of the glottis (*glottides*) can only be modified by those which raise or depress the trachea.

[*Note on the tracheal dilatation of the cassowary of New Holland.*—I discovered this remarkable dilatation, or pouch, connected with the trachea of the cassowary in 1824, and described it in the *Edinburgh Philosophical Journal*, l. x. It appears from what I learn from Meckel, that Fremery* had, in 1819, seen the opening in the trachea, but was entirely ignorant of the pouch, or bag, which he had no doubt cut away unskilfully whilst dissecting the neck. When in Paris, in 1825, M. Cuvier expressed a wish to see the trachea and pouch, and his assistant soon found for us the trachea, but, as in the case of Fremery, the pouch had been cut away and lost. From the same authority (Meckel) I learn that this singular structure had been afterwards described by Hausmann and Wedemeyer.

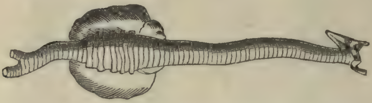

Fig. 320.—Trachea of the Emu, or Cassowary of New Holland.

The deficiency in the tracheal rings commenced at the 52°, and extended to the 62°; by this large opening the interior of the trachea communicated with a pouch not much smaller than the human head. I at first supposed it to be in part muscular, but I could not verify this on the dried preparation. The diameter of the opening was about 2½ inches. I believe it is found in both sexes. The purposes it serves in the economy of the cassowary have not been discovered ; at the time I made the discovery, I fancied that it might serve as a swimming bladder to the bird if suddenly placed in difficulty by the inundations for which Australia was remarkable. But this was, of course, a mere conjecture. The pouch is situated at the lower part of the neck, immediately above the sternum, and is thus well placed for a swimming bladder. It can be filled with air or emptied at the will of the bird. Meckel examined the bird during life, and observed that the pouch did not swell when the bird was made to run, but, on the contrary, evidently became dilated when at rest.—R. K.]

§ 442. Birds are oviparous, and the young require no nourishment from a breast. The period of incubation of the young in the egg varies with the species, but is nearly the same in the individuals of a species. For the humming-bird, the smallest of the class, the period is twelve days; for the canary, it varies from fifteen to eighteen days; for the domestic fowl, twenty-one days; twenty-five for the duck; and from forty to forty-five for the swan. The heat of the sun suffices for the incubation of some tropical birds, but in general it is quite otherwise, and the eggs require to be

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* Spec. Zool. Sistens Obs. Pr. Osteol de Casuaris, Nov. Holl. Tras. ad Rp. 1819.

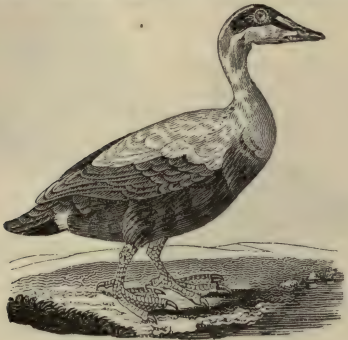

Fig. 321.—The Eider (Goose) Duck.

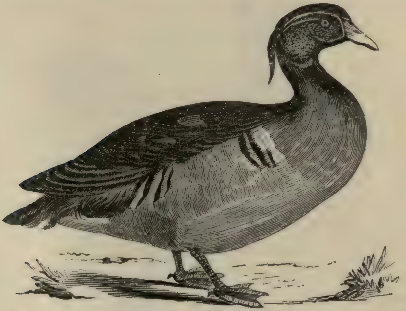

Fig. 322.—Carolina Duck.

placed in a nest, and carefully and sedulously hatched by the mother.

It is in the construction of the nest that birds display that wonderful hereditary instinct of which we have already spoken at considerable length; a few merely scrape a hole in

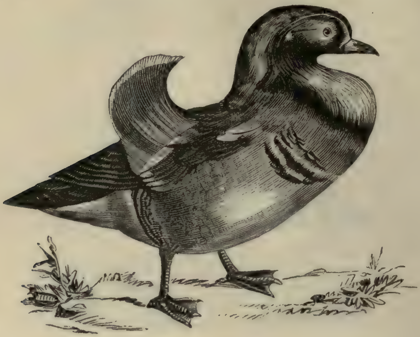

Fig. 323.—China Duck.

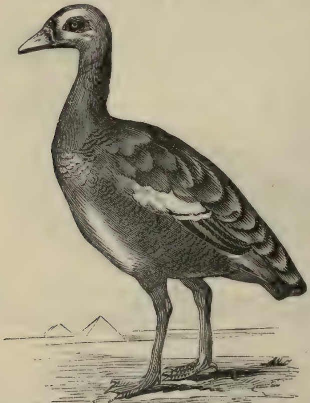

Fig. 324.—Egyptian Goose.

the soil, and deposit therein the egg or eggs to be hatched, but with the greater number it is quite otherwise, and the species may often be known by the form of the nest (§ 328). The warm and light substance, called eiderdown, used in domestic economy, is the soft down which the bird pulls from its breast to line the nest.

The lay of eggs (*ponte*) takes place generally once a year, sometimes twice; but in a domestic state, the fecundity is still greater. In the smaller species, the number of eggs exceeds that of the larger; the eagle lays but one or two; the tomtit and the raven, from fifteen to twenty.

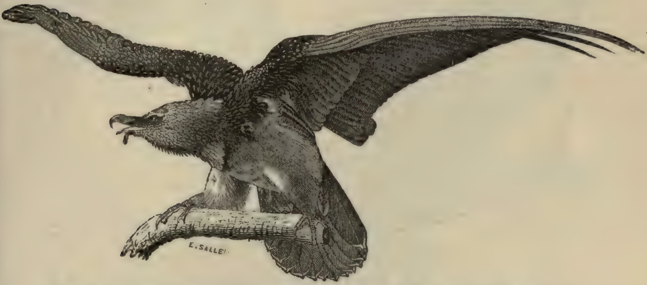

Fig. 325.—Gypaetos, or the Lamb-slaying Vulture; Bearded Vulture; Læmmergeyer.

The constancy with which the parents—sometimes the female only, sometimes also the male—hatch their eggs; the care they take of their young when they appear; the courage and intelligence shown by the parent bird in defending the young, are facts within the observation of all. Nevertheless, there are some birds, as the cuckoo, which deposit their egg or eggs in the nests of other birds; the young cuckoo gradually dislodges his companions from the nest, and occupies the whole. It afterwards rejoins its parents, which seem to remain in the neighbourhood for that purpose. Instinct leads the cuckoo to deposit its eggs in the nest of some insectivorous bird (that being the food on which its own young requires to be fed), such as the nests of the linnet, yellow-hammer, blackbird, &c.

Notwithstanding the strength of the instinct which leads birds to hatch their eggs, it seems certain that it may be modified by certain circumstances, Ostriches, for example, sit carefully on their eggs in temperate climates, but leave them in tropical regions to be incubated by the sun.* It would seem, also, that several of these large birds unite to lay their eggs in one nest, taking charge of them alternately.

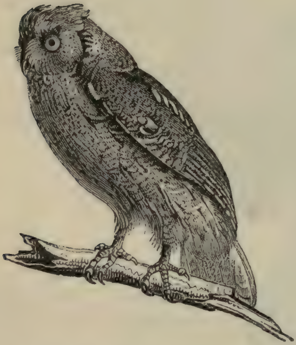

Fig. 326.—The Owl (Scops Vulgaris).

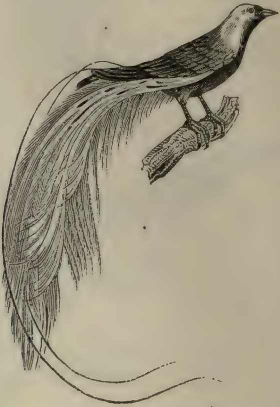

Fig. 327.—Bird of Paradise.

§ 443. We have already (§ 325) described at length the migratory instinct of birds, which induces them to migrate from one region to another at fixed seasons. The cause of this is explicable in some instances, but not in others; for certain species, it may be affirmed that the causes of these migrations are wholly unknown. In some experiments made on the young of migratory birds, it appears that the anxiety to leave comes on when these are detained in captivity and plentifully supplied with food.

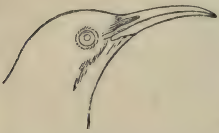

Fig. 328.—Sitta; Nut-hatch.

Upon the whole, atmospheric changes would seem most to influence migratory birds, and that such changes also modify the time of arrival and departure. In each species, however, the period is fixed, and may be calculated on. Occasionally, age modifies the time of flight or departure, the old leaving before the young.

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* Extremely doubtful.—R. K.

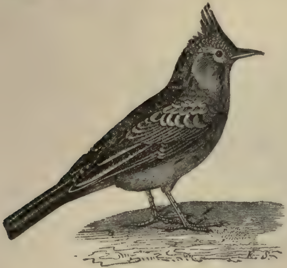

Fig. 329.—The Lark.

Fig. 330.—The Wren.

§ 444. It is also a remarkable circumstance in the history of birds, that they can leave their nests for so great distances, and yet return without the smallest difficulty or chance of mistake. Swallows, for example, year after year (for eighteen years, as proved by Spallanzani) return, young and old, suc-

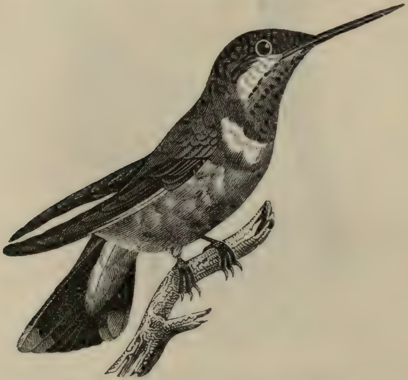

Fig. 331.—Colibri, or Humming Bird.

cessively to the place where they were produced, the young building their nests in the vicinity of those of their parents. Spallanzani removed a couple of swallows in a cage from the nest where they were hatching from Pavia to Milan; on being let loose they returned in thirteen minutes to their young.

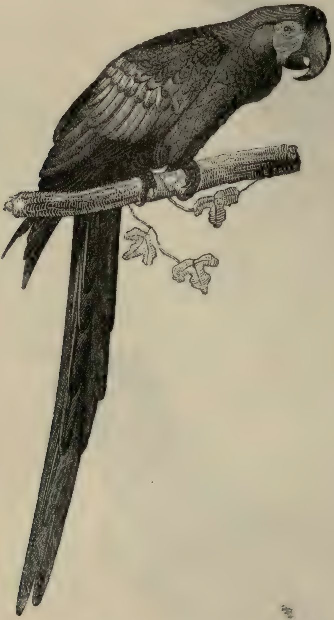

Fig. 332.—The Parroquet (Ara).

§ 445. The instinct of sociability has also been alluded to (§ 329, 330, 339), an instinct, however, which prevails mostly with insectivorous or granivorous birds. Birds of prey are generally solitary, or live only in pairs.

§ 446. Birds differ also in the manner in which they procure their food: some search for it by day, others by night, and some by twilight; and of these latter, it is sufficiently remarkable that they are of a sombre colour, with downy pinions, so that they strike the air without any noise. To this class belong the owl and goat-suckers, &c; their habits and structure are strictly in unison.

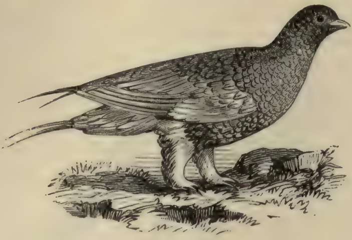

Fig. 333.—Pallas; Land Grouse of China.

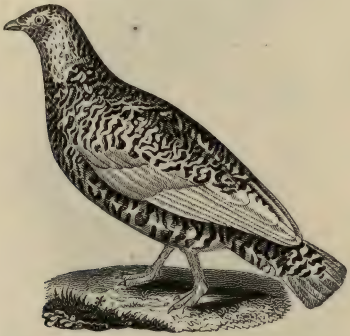

Fig. 334.—The Ptarmigan (Lagopus), White Grouse.

§ 447. The species known to naturalists amount to seven thousand, and their classification is difficult by reason of the great uniformity of their structure. Their distinguishing characters, as being in relation with their *régime*, have been taken chiefly from the conformation of the bill and legs.

Cuvier, whom we follow, divided them into six orders,—namely, rapacious birds, passerines, climbers, gallinaceous birds, waders, and palmipeds.

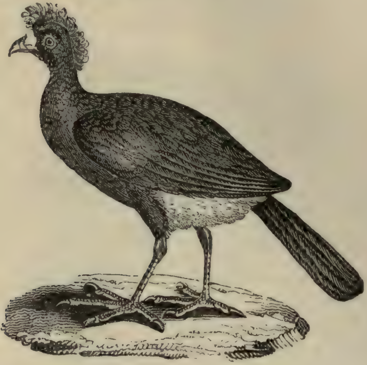

Fig. 335.—Common Hocco; Curassow; Crax Alector.

§ 448. The rapacious birds, or birds of prey, are recognised by their claws, their robust, short, and powerful bills, and the strength of their legs. Their aspect denotes their fierceness. Of these, some are diurnal, and may be known by their close plumage, and the lateral direction of their eyes.

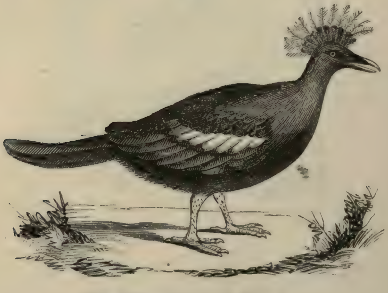

Fig. 336.—Crowned Pigeon.

These are, the vultures (Fig. 305), the læmmergeyers (Fig. 325), the falcons, the eagles (Fig. 295), the sparrowhawks, the kites (Fig. 302), the buzzards, &c. The others are nocturnal, and constitute the family of the owls, known by their downy plumage and the anterior direction of their eyes.

§ 449. The order passerine have their legs slender, feeble, and formed in the usual way, neither armed with claws nor elongated like stilts, and with a single toe, directed backwards. The bill is feeble (Fig. 328), straight, or but little curved (Figs. 329, 330); their wings are sufficiently large; and they are all small or of moderate size, and have slight and light forms.

Some live on insects, others on grain, and others are omnivorous, and to this order belong all singing birds and most birds of passage.

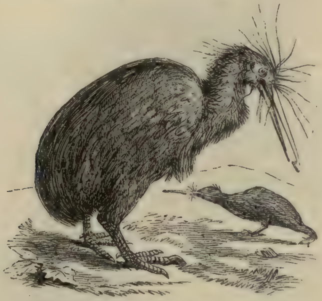

Fig. 337.—Apteryx of New Zealand.

The number of the passeres is immense: as specimens we may mention the blackbird, linnet, swallow, goat-suckers (Fig. 308), lark (Fig. 329), sparrows, crow, bird of paradise (Fig. 327), the colibri or humming-bird (Fig. 331), the wren (Fig. 330), kingfisher (Fig. 310), and the calao (Fig. 312).

§ 450. The climbing birds have, with the *régime* and the ordinary organization of the passeres, two toes directed forwards and two backwards; hence the facility with which they climb in all directions. In this division are arranged the tùcans—remarkable for their enormous bills, the parroquet (Fig. 332), the cuckoo, the woodpecker (Fig. 291), &c.

§ 451. Gallinaceous birds have the bill moderately enlarged above, and adapted only for a granivorous *régime;* the wings are short, the body heavy, the legs moderate, and the toes feeble, but united generally at their base by a small cutaneous fold. The majority of these birds fly badly; they do not build their nests in trees, and they seek for their food on the soil. This order is composed of two distinct families; that of pigeons and that of the gallinaceous birds, properly so called, comprising the cock, the pheasant, the peacock, the turkey, the pintado or guinea-fowl, the hocco (Fig. 335), the partridge, the quail, the ptarmigan (Fig. 334), the grouse, &c.

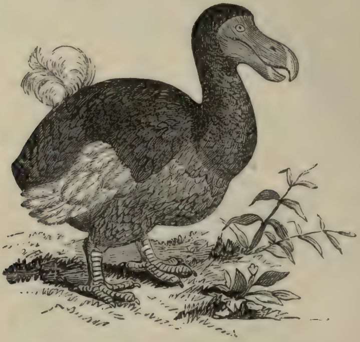

Fig. 338.—The Dodo (Didus Ineptus).

[In 1598, when the island of Mauritus was first discovered, this bird, which is now in all probability extinct, abounded there; it seems to have been extirpated by the European sailors who frequented the island. A few specimens were brought to Europe, and one found its way to Oxford. To the east of the Mauritius and Bourbon is the little island of Rodriguez (where the dodo also abounded), on which three species of wingless birds once existed; they seem to have belonged to the same natural family as the dodo, now extinct. Leguat* was also supposed to have described the dodo; also François Coache; there thus arose the utmost confusion in respect of the true nature of these birds. The latest researches on this subject, by Messrs. Strickland and Melvill, arrange the extinct dodo with the columbidæ, or pigeons. —R. K.]

* A French voyager.

§ 452. The waders (échassiers) are known by their elevated tarsi, and their legs without feathers inferiorly, a structure which gives them the appearance of walking on stilts, favourable at once to rapid movement and to wading in fordable waters. Their height is in general elevated, and the length of their neck is such that, however elevated their legs, they can collect their food on the ground without stooping. Some live on herbs, others on aquatic reptiles, others on small fishes. The birds called *oiseaux de rivage*, frequenting the banks of lakes and rivers, belong to this division,—such as the heron, the crane (Fig. 339), the stork (Fig. 306), the bittern (Fig. 340), the woodcock, the ibis (Fig. 292), the courser (Fig. 297), the water hen, the flamingo (Fig. 342), and some other genera which live not near the waters, but resemble the preceding in their conformation, — such as the ostrich (Fig. 296), the cassowary (Fig. 282), and the bustard.

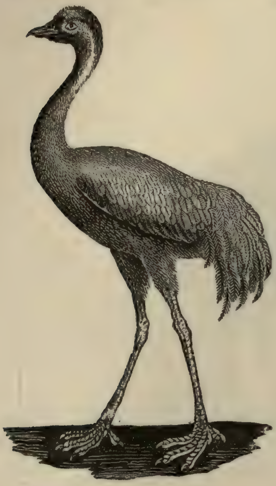

Fig. 339.—The Crane.

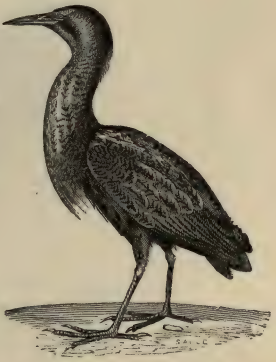

Fig. 340.—The Common Bittern of Europe.

§ 453. Finally, the palmipeds or swimming birds are characterized by their legs, of moderate length, terminated by large webbed feet. These serving the purpose of oars, are formed by the toes being united to each other by an interdigital membrane of the common integument; the legs are placed far back, which is favourable for swimming, but ill adapted for walking: as examples of this group we may mention the auks (Fig. 294), the penguins, which have the wings so short that they cannot fly; the petrels, the albatrosses, the gulls, and the terns (Fig. 343), which have, on the contrary, long wings, and a powerful flight; the pelicans (Fig. 311), the frigate birds, and the boobies, which are as well organized for flight as the preceding, and the first still more completely webbed; finally, the swans, the geese, and the ducks (Fig. 300), whose bills are covered with a soft skin instead of a horny envelope.

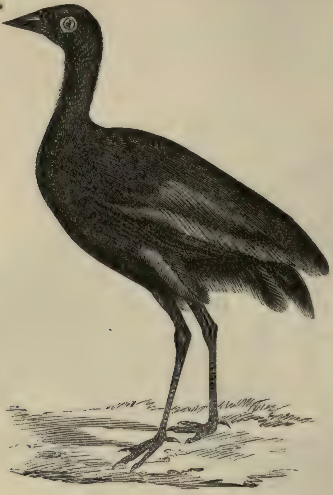

Fig. 341.—The Trumpeter Bird.*

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* Attempts are now being made to acclimatize this South American bird in the South of France.

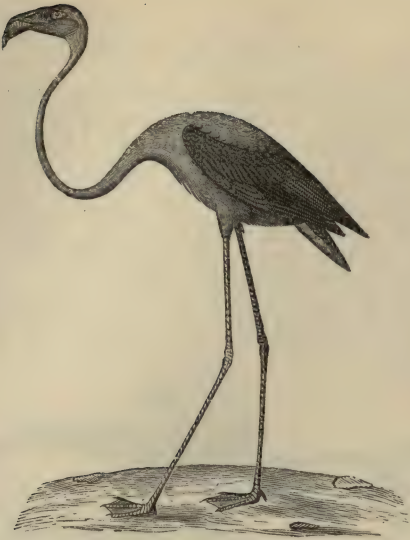

Fig. 342.—The Flamingo.

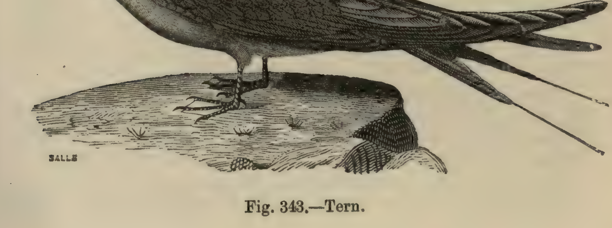

Fig. 343.—Tern.

CLASS OF REPTILES.

§ 454. The class Reptiles comprises all vertebrate animals whose respiration is from birth *aërienne* and incomplete. They have lungs, like mammals and birds; but their circulatory apparatus is always so arranged that a portion of the dark blood mingles with the arterial, without having traversed the respiratory organs; and generally this admixture takes place in the heart, which has in that case but a single ventricle communicating with two auricles (§ 108). Finally, the skin of reptiles is generally or almost always covered with scales. In their general form they resemble mammals more than birds; but in this respect they vary. The tortoise (Fig. 345), lizard (Fig. 344), and serpent (Fig. 346), have very different forms.

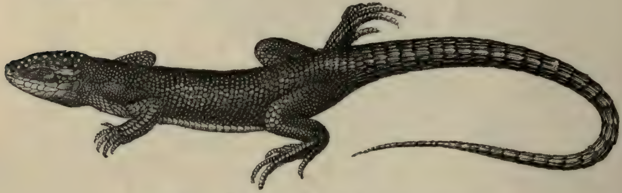

Fig. 344.—The Green Lizard; Lacerta viridis.

Their head is almost always small, and their body very elongated; some, as serpents, are entirely without limbs, or have only vestiges of them (Fig. 272); but most of these animals, the lizard for example, have four limbs, constructed so as to serve for walking or swimming. Nevertheless, their limbs, when present, are so short as to allow the body to touch the soil, and in place of being directed parallel with the axis of the body, and consequently to move in this direction, move perpendicularly to their axis, and from side to side. Hence the name reptile.

§ 455. Their skeleton presents in its structure variations much greater than what occurs in hot-blooded vertebrate animals. All its component parts may in their turn be wanting, excepting the head and vertebral column; but the bones composing it preserve great analogies and homologies with the hot-blooded vertebrata, and exhibit analogies with the other classes.

§ 456. The cranium is always small, and the face elongated. As in birds, the lower jaw is composed of several distinct pieces, and is articulated as in them with the *os quadratum* or tympanic bone. Even this bone is sometimes suspended to a moveable lever, as in serpents, by which the dilatability of the mouth is greatly increased. The upper jaw is in general immovable, but is so articulated in serpents as to perform some movements. In several, as in lizards and tortoises, the bones of the cranium are extended over the temporal spaces like a buckler, thus causing the head to appear large. Finally, the head is generally not very moveable, and is articulated with the column by a single condyle with several facettes.

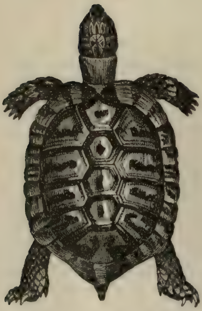

Fig. 345.—Common Land Tortoise.

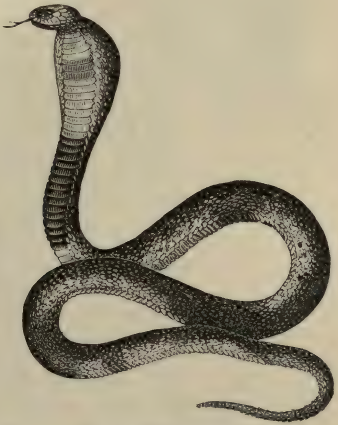

Fig. 346.—Egyptian Aspic.

§ 457. In lizards and crocodiles, and other reptiles formed after the same way, there are in general but few anomalies; the ribs are more numerous than in birds and mammals, and protect the abdomen as well as the chest. Serpents have neither sternum nor limbs, and the free extremities of the ribs seem to be used as organs of locomotion. In the couleuvre (adder or snake) there are more than three hundred pairs of ribs. The vertebræ also, by their mode of articulation with each other (a kind of ball-and-socket), permit of extensive movements. But the most remarkable modification of the skeleton is in the tortoise and turtle; the bones form a buckler, within which the animal may withdraw itself on the approach of danger. The dorsal osseous plate is called the *carapace;* the ventral, *plastron* (Fig. 348). United at the sides, they leave in front and behind openings for the head and limbs. This kind of cuirass is only covered by the skin, which in its turn is protected by large horny plates: all the muscles and other soft parts are contained within the cavity thus formed.

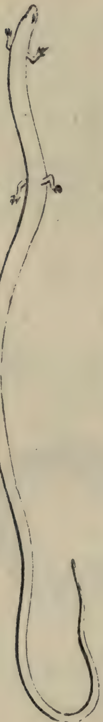

Fig. 347.—Chalcis; an elongated Lizard.

§ 458. Notwithstanding the profound modifications which the skeleton undergoes to meet such an organization, we find the same elements or pieces which constitute the skeleton in the other vertebrata merely changed in form and volume.

When we examine the carapace (dorsal plate) superiorly, we find it composed of a great number of osseous plates, united by sutures, of which eight occupy the median line; sixteen others form on each side a longitudinal row; and twenty-five or twenty-six surround the whole. We have only to look at the inner side of the carapace (Fig. 349) to see that these median pieces are simply dependencies of the dorsal vertebræ (*vd*). The body of each of these bones and the canal for the spinal marrow may be seen, with their ordinary shape, but the upper portion of the osseous ring has been spread out like a disc, uniting with the same parts belonging to the preceding and following vertebræ. The dorsal vertebræ become thus immovable: each carries a pair of ribs as in man, but these (*c*) spread out so as to touch each other throughout almost their whole length, and to articulate with each other by means of sutures; finally, the marginal pieces (*cs*) which articulate with the extremity of the ribs, and which form in some measure the border of the carapace, evidently represent the sternal portion of these ribs, which in mammalia remain cartilaginous, but which in birds are completely ossified. In some tortoises they remain cartilaginous, and in almost all these animals several of them are supported laterally on the edges of the plastron or ventral plate.

The plastron is formed by the sternum, which presents an extraordinary development, and extends from the base of the neck to the commencement of the tail. The bones composing it are nine in number, arranged in pairs, and so articulated with each other as to form a great oval plate. The plastron is sometimes entire and solid throughout its whole extent, sometimes divided into three portions, of which the anterior and posterior are a little moveable; at other times it is hollowed out in the centre like a picture-frame. Finally, it is fixed on each side to the carapace by bone or by cartilage. All the muscles and soft parts, as well as the organs, are contained within these two plates.

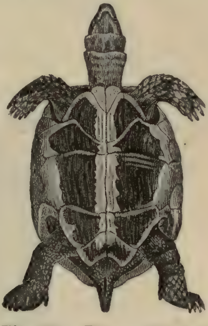

Fig. 348.—The Common Land Tortoise (Testudo Græca), as seen from below.

The bones of the shoulder (*o*, *cl*, *co*) articulate with the vertebral column on the one hand and the sternal on the other. One of these bones (*o*) suspending it to the vertebral column is evidently the scapula; a second, directed backwards (*co*), corresponds to the coracoid bone of birds; and the third (*cl*) represents the clavicle, or at least the acromial process of the scapula, with which it generally articulates.

The pelvis (*b*) greatly resembles the osseous girdle formed by the bones of the shoulder; it is also composed of three distinct pairs of bones: the iliac bone, attached to the transverse processes of the posterior vertebræ of the carapace, a pubis, and ischium directed towards the plastron, and united to the corresponding bones of the other side.

§ 459. In other reptiles, the bones of the shoulder more resemble those of birds. The limbs generally have nothing remarkable; sometimes they are truncated at the extremity, as in the land tortoise; sometimes they terminate in slender fingers, as in the lizard; and at other times the extremities of the fingers and toes are broadened out, as in the gecko (Fig. 350); and being provided with short cutaneous folds performing the office of suckers, they enable this hideous

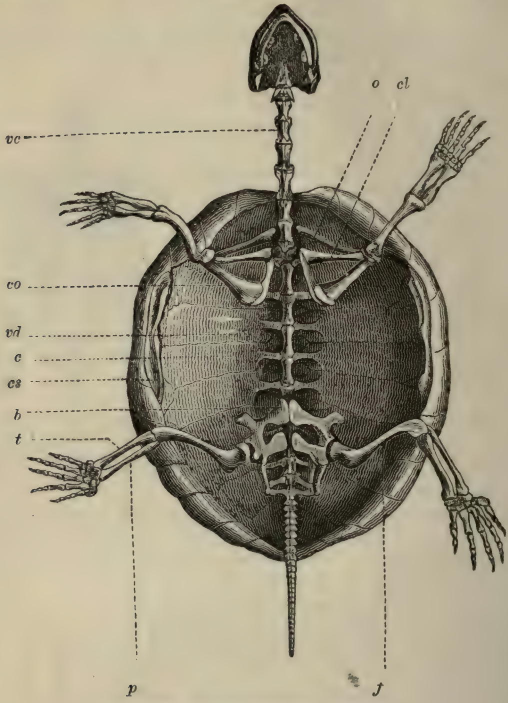

Fig. 349.—Skeleton of the Tortoise.*

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* Skeleton of the Tortoise; the plastron has been removed: *vc*, cervical vertebræ; *vd*, dorsal vertebræ; *c*, ribs; *cs*, sternal ribs,—the marginal bones of the carapace; *o*, scapula; *cl*, collar-bone; *co*, coracoid bone; *b*, pelvis; *f*, the femur; *t*, tibia; *p*, fibula.

animal to creep along the smoothest walls, and even along the ceiling.

There are also reptiles which have the fingers capable of being opposed to each other as in the hand of man: in the chameleon (Fig. 351) they are arranged into two packets, enabling them to hold on to the branch; they have also a prehensile tail, and thus they are in fact climbing animals.

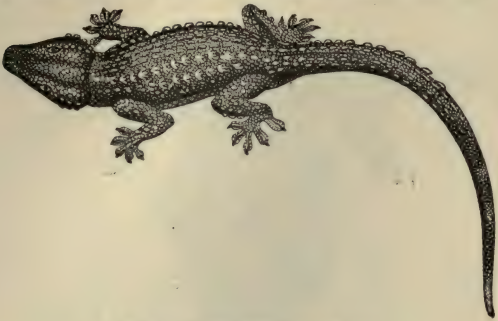

Fig. 350.—The Gecko of the Walls.

Finally, in other reptiles more formed for an aquatic life, the feet and hands are formed like oars: the turtle (Fig. 52) is the only reptile which at present offers us this kind of structure; but in remote epochs of the geological history of the globe, our seas were peopled with large animals with

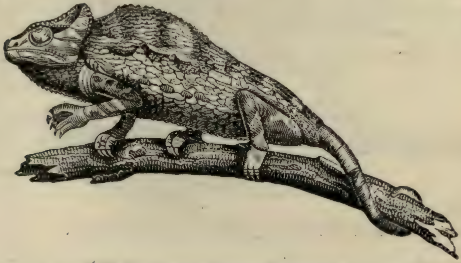

Fig. 351.—The Common Chameleon.

swimming paws resembling oars, and having many points of resemblance with the reptiles and serpents of the present day. Modern anatomists have called them ichthyosauri (Fig. 353) and plesiosauri (Fig. 354); and their fossil skeletons have been found entire.

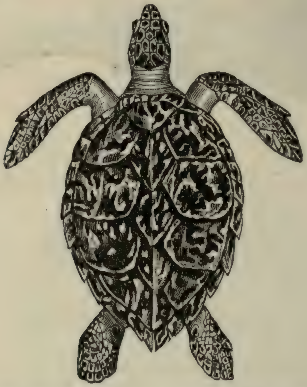

Fig. 352.—The Turtle (Testudo Caretta). Loggerhead Turtle.

Winged reptiles also exist. The dragons (Fig. 355), animals resembling lizards, have a large fold of skin placed along the flanks, resembling the wings of the bat, but are supported only by the first six false ribs extended horizontally in a straight line. It uses this merely as a parachute in dropping from branch to branch; it inhabits India: thus realizing to a certain point the flying lizards or serpents of which some writers have spoken. But the dragons of naturalists attack only insects.

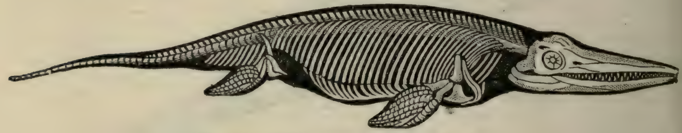

Fig. 353.—Ichthyosaurus; a fossil animal.

During the epochs of the great saurians on the earth, there existed a flying reptile still more singular than the dragon. It has been called the pterodactyle; it was a saurian, made somewhat like a bat; it could walk or fly, but the little finger of the hand was thrice as long as the trunk, and no doubt supported folds of integuments resembling wings (Fig. 356).

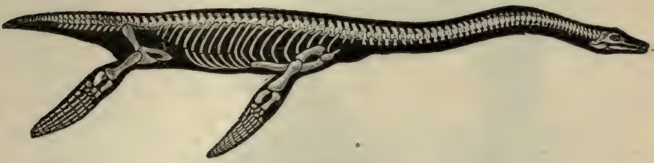

Fig. 354.—Plesiosaurus; a fossil animal.

§ 460. Reptiles are less quick in their movements than birds or mammals, nor can they sustain their movements so well, probably owing to a less energetic respiration. The muscles receive less blood, and are paler; but they may be excited long after death by a variety of stimulants. The tail of a lizard detached from the body, has been seen to move for several hours; and the turtle, dead in appearance for several days, may still be made to move its limbs. The mutual dependence between the nervous and muscular systems seems not to be so intimate as in mammals.

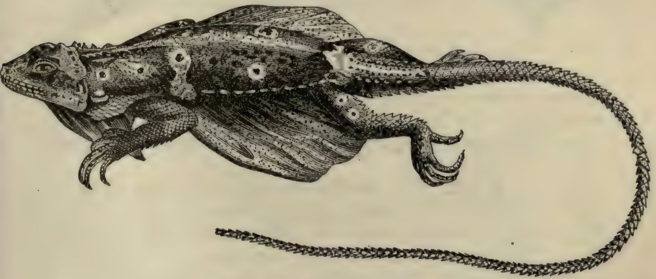

Fig. 355.—The Dragon.

§ 461. The brain is small, smooth, and without circumvolutions (Fig. 357). The hemispheres are hollow, and there is no striated body. Olfactory globules of considerable size are situated at the origin of the first pair of nerves. The optic lobes are in general large, situated behind, and on the same plane as the hemispheres; but the little brain (cerebellum) is small, and it sends no prolongations across the medulla, so as to form a sort of ring, as in mammals. The spinal marrow, compared to the brain, is large; so also the nerves, as compared to the cerebro-spinal axis, are larger than in the superior classes of animals.

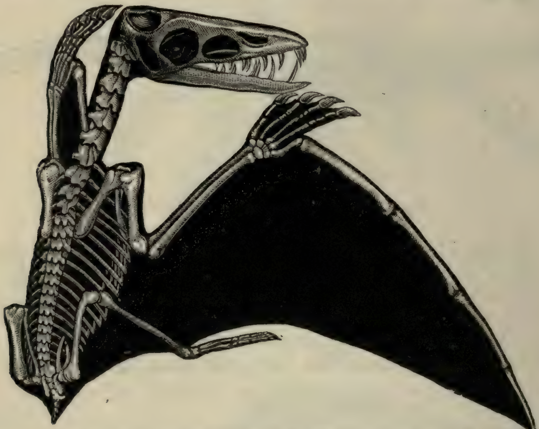

Fig. 356.—Pterodactyle; a fossil or extinct animal.*

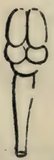

Fig.357.

§ 462. The tactile sensibility is but little developed, the skin being generally protected by horny scales; what we call tortoiseshell is merely the horny plates covering the carapace of the turtle (Fig. 352), the testudo caretta. The epidermis is frequently renewed, falling sometimes in portions or plates, and sometimes cast off entire, as in serpents. Serpents throw off the epidermic covering several times a year.

There is but little remarkable in the eyes of reptiles, but upon the whole they resemble the eyes of birds; a *pecten* is but rarely found. Some have three eyelids, in others they are wholly wanting, as in the serpent; to this may be ascribed its fixed look.

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* The black part indicates the presumed contour of the skin.

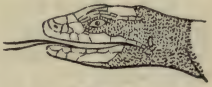

Fig. 358.

The auditory apparatus is much less complete than in mammals, or even in birds. The external ear is almost always completely wanting; there is no auditory canal, and the drum of the ear is on a level with the outer surface of the head; the tympanic cavity is imperfectly formed, and seems to be a sort of dependence of the pharynx. The bones of the ear most frequently are wanting, and the cochlea is often rudimentary; the organs of smell are but little developed; the tongue is sometimes thick and fleshy, but generally thin, dry, and protractile; in serpents (Fig. 358) and lizards it is bifid: in the chameleon the tongue becomes an instrument of prehension, for it can be darted from the mouth to the distance of several inches, and thus flies and other small insects are caught by means of a viscous ball which terminates it.

§ 463. Few reptiles live entirely on vegetable food; they are almost all carnivorous, and pursue a living prey, which they swallow entire. The mouth is almost always large in the cleft, and is so dilatable in serpents as to enable them to swallow animals having a larger diameter than themselves. The two branches of the lower jaw (*mi*, Fig. 359) are united only by ligament, and the tympanic bone (*t*), and the mastoid bone (*ma*), by means of which the lower jaw is articulated to the cranium, are both moveable, and thus the

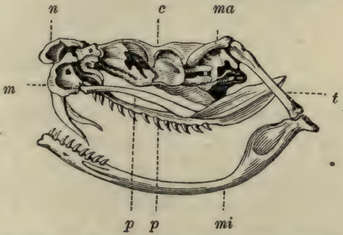

Fig. 359.—Head of the Crotalus, or American Rattlesnake.

jaws admit of very great dilatation; moreover, the branches of the upper jaw (*m*) are attached to the intermaxillary bones also by ligaments, and even the palatine arches partake of the movement. Their teeth are intended only to seize their prey, and after swallowing it they remain long in a state of torpidity.

§ 464. Many serpents, such as the viper, the cobra, the rattlesnake, and the trigonocephalus or brown viper of Carolina, possess a dangerous venomous apparatus of an alarming character. Certain glands, analogous to the salivary, secrete this poison (Fig. 360); they are placed under the temporal muscles, so as to be compressed by them when in action. They communicate by a canal with a fang or poisoned tooth on either side; this is either grooved or perforated by a canal, the exit of which is not at the point, but a little higher up, so as not to interfere with the action of the point of the tooth. When the animal bites, the venom is by this means transfused into the bottom of the wound. These teeth are fixed, but the bones to which they are attached are moveable; when not in use they lie horizontally, with the palate, encased in a sort of sheath of mucous membrane. The poison itself is neither acrid nor burning to the taste, and it is harmless when swallowed; its terrible effects are felt only when mingled with the blood in a wound, and they vary with the condition of the animal. On some animals the poison of the viper has no effect, as on leeches, slugs, the common snake, and the civet; whilst it

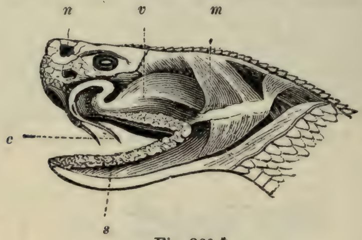

Fig. 360.*

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* Poison apparatus in the Rattlesnake:—*v*, poison gland, with its duct leading to the large poison fang (*c*); *m*, elevator muscles of the jaw, which partly cover the gland, and may compress it; *s*, salivary glands on the edge of the jaws; *n*, the nostril, under which is the little cavity distinguishing these serpents and the trigonocephali from vipers.

kills with the greatest rapidity all hot-blooded animals, the lizard, and the viper itself. A grain of the poison of the viper will kill a sparrow, but it will require six times as much to kill a pigeon. As the poison acts through the circulation, the most rapid means must be adopted to prevent absorption, such as washing with water and strong spirits, a ligature round the part bitten, and, if possible, its excision. Ammonia has been much celebrated as an antidote, but it cannot be depended on. The Indians of South America consider as a powerful antidote a plant called guaco, or micania guaco; they assert not only that the application of the leaves of this plant to the wound prevents all dangerous effects, but that the inoculation of the juice of the plant will prevent such bites having any bad effects. Humboldt thinks that there may be something in the odour of the plant which may prevent the serpent from biting the person. The serpents with fangs called moveable are the most dangerous; the fangs are not in fact moveable, but attached to very small maxillary bones, which are so. In general you find one fang fixed in either side, with several others of different stages of growth, ready to replace them when lost, which probably happens at regular periods. The poisoned fangs are shed by a process analogous to what takes place in the teeth of fishes. In the viper, rattlesnake, cobra, and several others, the upper maxillary bones carry poison fangs only; and thus between them and the common snake there is this marked difference, that the maxillary and palatine bones in the upper jaw carry each a row of teeth, giving an appearance of four rows to them, whilst in the true poisonous serpents just mentioned we find only two rows, the palatine only; but in the venomous water snakes, and in many others, the superior maxillary bones carry simple teeth as well as the poisonous fangs. Some reptiles have no teeth, such as the tortoise and turtle, a horny layer like the bills of birds supplying their place.

§ 465. There is never any pendulous palate, and in most the pharynx is not distinct from the mouth, nor the gullet from the stomach. The intestines are short, and have no cæcum; the large intestine differs but little from the small, and terminates in a cloaca, as in birds; they have lymphatic and lacteal vessels.

§ 466. We have already remarked that their blood is not rich in globules, and that these are large and elliptic. The disposition of the circulatory apparatus varies (§ 108), but, as we have said, there is always a direct communication between the vascular system carrying red blood and that carrying dark blood, and thus the organs receive a fluid imperfectly acted on by respiration. The heart is almost always composed of two auricles (Fig. 361), opening into a single ventricle. The arterial blood coming from the lungs, received into the left auricle, and the venous blood coming from different parts of the body and collected in the right auricle, are both poured into the single ventricle; in this they are mingled together. A portion of this mixture returns by the aorta into the different organs it is intended to nourish, whilst another part proceeds to the lungs by vessels which spring immediately from the common ventricle or from the aorta itself. In crocodiles, the heart (Fig. 362) more resembles that of birds and mammals, having a septum separating the right ventricle from the left; but a peculiar disposition of the arteries causes the mixture of the dark and red blood to take place at some distance from the heart, and thus the posterior half of the body receives blood imperfectly arterialized. In fact the right ventricle, instead of sending off one artery, the pulmonary, sends off two, one of which winding behind the heart, unites with the descending aorta, but not until all the vessels have been given off which go to the head and forepart of the body. With regard to the distribution of the arteries in reptiles, we shall limit ourselves to the remark, that there exist two or more aortic arches, bending to the right and left, and reuniting to form a single trunk (Fig. 5 1).

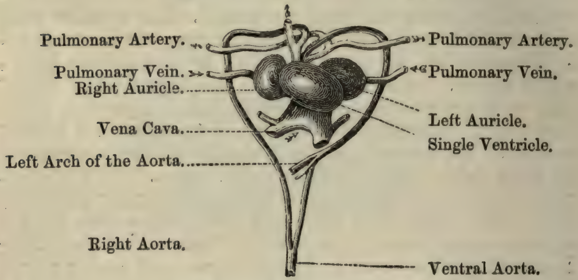

Fig. 361.—Heart of the Turtle.

§ 467. Respiration is not active in reptiles; they consume but little oxygen, and can remain alive for a long time without air; but this activity differs according to the temperature of the season. The lungs are composed of large cells, and in consequence are not very vascular. The tortoise and turtle swallow the air, as it were, the ribs being immovable; there is no natural division between the chest and the abdomen, and respiration is not regular; in serpents one lung is rudimentary (Fig. 363).

§ 468. All reptiles are cold-blooded animals, and the temperature of their bodies rises and falls with that of the surrounding medium. A heat of from 40° to 50° (Centigrade scale) is quickly fatal to most of them, and the effects of cold are well known, for during winter most reptiles eat no food, and do not even digest what happens to be in their stomachs; the respiration becomes slower, and their whole state resembles hybernation.

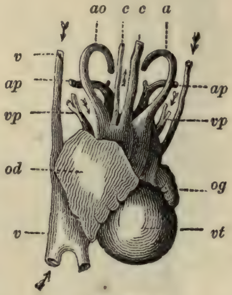

Fig. 362.*

§ 469. Like birds, they lay eggs, and their young do not suckle; they have no mammæ; but there is this peculiarity, which also happens in some fishes, that in some the young are hatched before being born, as in the viper; and such animals are called *ovoviviparous*.

The young reptile, on quitting the egg presents nothing anormal; it resembles its parent in its mode of respiration, general structure of the body, and external form.

§ 470. Reptiles generally abandon their eggs when laid, and the young are developed by the heat of the external atmosphere; but there is one remarkable exception in the great Indian serpent, called python, which hatches its eggs, during which period its own temperature will rise to 40°.

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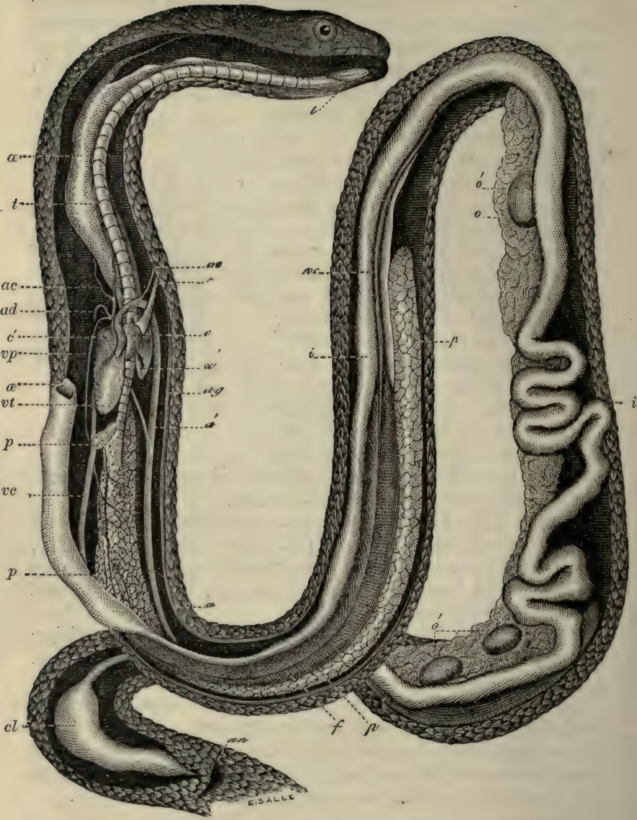
* Heart and large vessels of the Crocodile:—*v*, *v*, veins which bring back blood from different parts of the body to the right auricle (*od*); *vt*, the two ventricles, internally separated by a partition; *ap*, the two pulmonary arteries proceeding from the right ventricle to the lungs; *a*, a vessel proceeding from the same ventricle to the descending aorta; *vp*, pulmonary veins carrying the arterial blood from the lungs to the left auricle (*og*), from whence it passes into the left ventricle, and thus enters the aorta (*ao*) and into the two arteries (*c c*) which proceed to the head, &c.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E. SALLE

Fig. 363.—Anatomy of the Coluber (Common Snake).*

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* *l*, tongue and glottis; *œ*, gullet, cut across at *œ'* to show the heart, &c., *in situ;* *i*, the stomach; *i'*, the intestine; *cl*, cloaca; *an*, anus; *f*, the liver; *o*, the ovarium; *o'*, the ova or eggs; *t*, windpipe; *p*, principal lung, *p'*, little lung; *vt*, ventricle; *c*, left auricle; *c'*, right auricle; *a*, left aorta; *ad*, right aorta; *a'*, ventral aorta; *ac*, carotid arteries; *v*, superior cava; *vc*, inferior cava; *vp*, pulmonary vein.

Reptiles are divided into three orders: chelonian, saurian, and ophidian.

The chelonian (tortoise and turtle) have four limbs; the skin covered with large scales; the mouth without teeth; the jaws provided with a horny bill or covering; the ribs immovable, and in them we find the horny dorsal and ventral plates called *carapace* and *plastron,* already described.

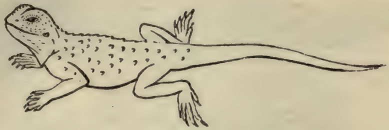

Fig. 364.—The Agama; a kind of Lizard.

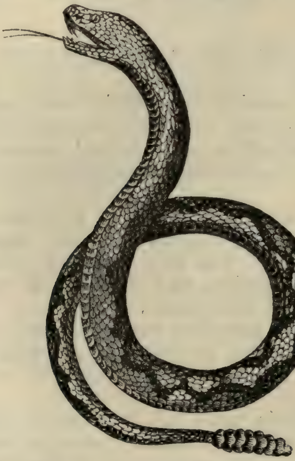

Fig. 365.—Crotalus, or Rattlesnake.

The saurian or lizard-shaped reptiles, and the ophidians or serpents, have the ribs and dorsal vertebræ moveable; a scaly skin; and teeth. The two orders run into each other, but it is generally agreed on to call those with limbs saurian, and those without, ophidian: as ophidian may be cited the viper, rattlesnake (Fig. 365), cobra (Fig. 346), as venomous; and as harmless snakes, the common snake or coluber, the boa,* and python. The order saurians comprises crocodiles (Fig. 366), lizards, chameleons (Fig. 351), geckos (Fig. 350), the agama (Fig. 364), the iguana, &c.

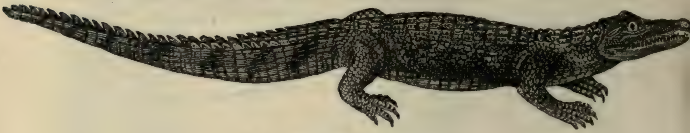

Fig. 366.—The Crocodile.

CLASS OF BATRACHIANS.

§ 471. The batrachia or amphibia were long confounded with the reptilia; when young they breathe by branchiæ or gills, and resemble fishes in the general conformation of the body; but they change their forms and acquire lungs before becoming adult.

Like fishes and reptiles, they are cold-blooded animals, their circulation is incomplete, and their respiration comparatively inactive. The skin is naked or unarmed, the skeleton very incomplete, and the heart is composed of a single ventricle and two auricles.

In their external form they vary considerably, some resembling lizards, and even serpents, but generally the body is flat, short, and thick, without a tail, with well-developed limbs.

§ 472. In their mode of development they resemble fishes; whilst in the egg, the young animal is not surrounded by the membrane called *amnion*, and which is always present in the three preceding classes; neither have they an *allantois*, which plays an important part in the economy of the chick and of the young of reptiles during incubation; at birth, they strongly resemble fishes.

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* Travellers are cautioned not to be misled by the names given to serpents by naturalists. The *boa fasciata* of Schneider is a most venomous and dangerous snake.—R. K.

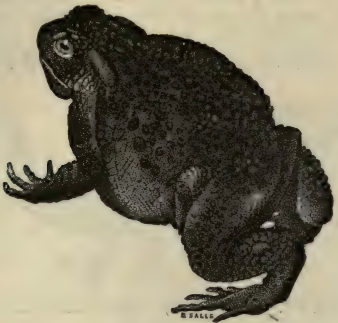

Fig. 367.—The Toad.

The young batrachia are known by the name of tadpoles (*tétards*), and are formed for an aquatic life: at birth they have a tail, but no feet; gills projecting externally (*b b*, Fig. 368), and their skeleton is cartilaginous.

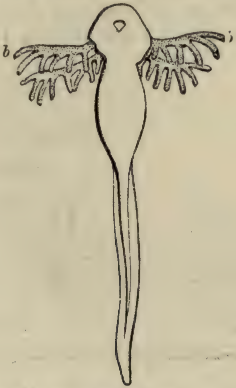

Fig 368.—Tadpole of the Frog.

These projecting gills or branchiæ in some continue throughout life, as in the proteus, axolotl (Fig. 369), and siren. But in most batrachia these branchiæ soon wither away and disappear, although the aquatic life continues, for the tadpole has internal branchiæ, like fishes, as well as external (Fig. 370); these fixed or internal branchiæ in the tadpole are attached under the neck to cartilaginous arches belonging to the hyoid bones, and are protected by the skin; the water reaches them by the cavity of the mouth, and escapes by one or two orifices situated under the neck. In the tadpole of the frog, the hind feet appear first, and they become of some length before the fore feet are visible; these appear later (Fig. 372). In the salamanders it is the opposite; finally, in the siren the hind legs never appear. The tail of the tadpole continues to grow in the salamander and proteus with the rest of the body; but in frogs and in many others

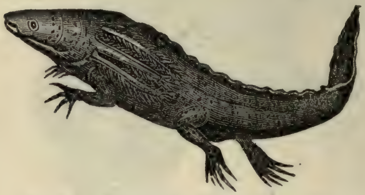

Fig. 369.—The Axolotl; a Mexican Lizard.

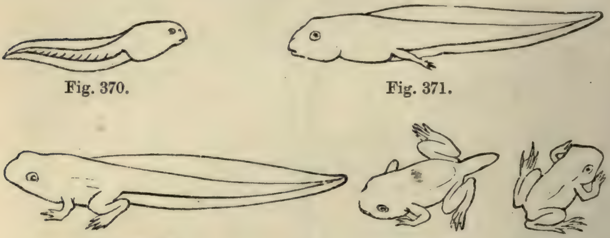

Fig. 370. Fig. 371.

Fig. 372. Fig. 373. Fig. 374.

Figs. 370—374.—Metamorphoses of the Tadpole of the Frog.

the tail wastes away and disappears (Figs. 373, 374). About the same time the lungs appear, and begin to perform their functions, so that at this period the tadpole is strictly an amphibious animal; but although this strictly amphibious state continues in some, in general it does not; the gills disappear, and in the adult there remain no traces of such an apparatus.

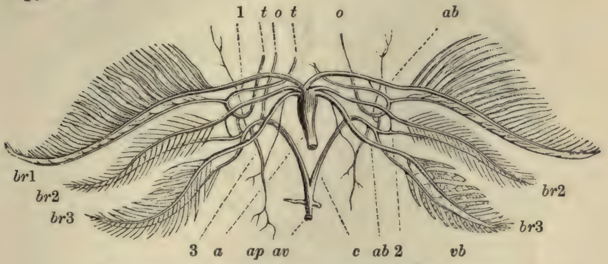

Fig. 375.—Bloodvessels of the Tadpole of the Frog.[*]

The circulatory apparatus also undergoes important metamorphoses. The heart of the adult batrachian is composed of two auricles and a ventricle, whence springs a large artery, bulbous (*like that of fishes*) at its commencement, and which soon divides to form the two arches of the aorta; but when the young animal breathes by branchiæ only, the blood expelled from the ventricle is distributed to the gills (*as in fishes*), whence it proceeds, for the greater part, to the dorsal

[*] *a*, artery arising from the single ventricle, and dividing into six branches (*ab*), which go to the three pairs of branchiæ, and ramify there—they are called branchial arteries; *br*, the branchiæ, showing the distribution of the branchial arteries upon them, and carrying the blood to them and the branchial veins (*vb*), bringing back the blood from them after it has been exposed to the oxygen of the atmosphere contained in the water sent across the gills: those of the two last pairs of branchiæ unite to form on each side a vessel (*c*) which, anastomosing in its turn with that of the opposite side, forms the ventral aorta or dorsal artery (*av*), which, proceeding backwards, distributes the blood to the greater part of the body. The branchial veins of the first pair of branchiæ curve forwards, and carry the blood towards the head (*t*, *t*); 1, a very fine and anastomotic branch unites the branchial artery and vein together at the base of the first pair of branchiæ, and this enlarging afterwards, allows the blood to pass between those two vessels without passing across the gill; 2, a small anastomotic branch, uniting in the same way the artery and vein of the second pair of branchiæ; 3, a vessel which, by uniting with a small branch situated more inwards, connects the artery and vein of the posterior branchiæ; *o*, orbitar artery; *ap*, rudimentary pulmonary arteries.

artery, whose branches ramify in the different organs (Fig. 375). We have already seen, that in fishes the blood follows the same course (§ 109), but when the lungs are developed, the disposition of the vascular apparatus changes; a direct

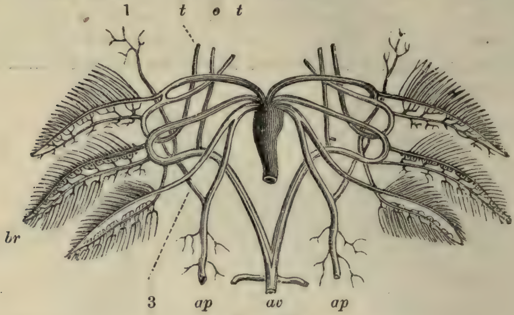

Fig. 376.*

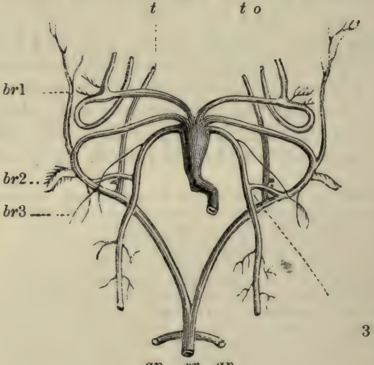

Fig. 377.

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* Fig. 376. The same parts as in Fig. 375 in a tadpole, in which the branchiæ begin to lose their importance, and in which a part of the blood proceeds from the heart to different parts of the body without traversing these organs. The same letters indicate the same vessels as in the preceding figure, and it will be remarked that the anastomotic branches (1, 2,

communication is established between the arteries which carry the blood to the gills and those which receive it from those organs, so that the blood is no longer obliged to traverse the gills in order to reach the dorsal artery, and thence to be distributed to the various parts of the body. The artery (*a*) which springs from the ventricle, and which may at this time be called a branchial artery, becomes then the origin of the dorsal vessel, and constitutes with it a true aorta, certain branches of which proceeding to the lungs, thus

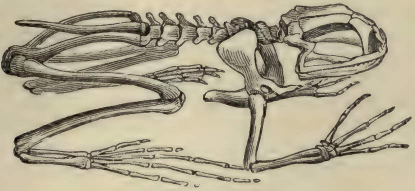

Fig. 378.—Skeleton of the Frog.

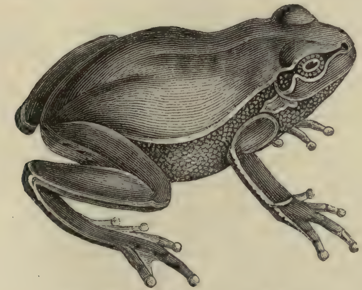

Fig. 379.—Rainette; Tree Frog.

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3), which in the preceding tadpole were merely capillary, are now large, and that it is with them rather than with the branchial vessels that the arteries coming from the heart seem to be continued. The pulmonary arteries are also much developed.—Fig. 377. The same parts in the perfect animal, indicated by the same letters; the vessels which in the tadpole went to the two branchiæ of the second pair, are continued now with the aorta by the intermedium of the anastomotic branches (2), and thus constitute the two aortic arches.

develop and establish a pulmonary circulation. Finally, the branchial vessels are obliterated, and then the circulation takes place nearly as in other reptiles. The venous blood returning from all parts of the body, is poured into the ventricle by one of the auricles, and is therein mingled with the arterial blood arriving from the lungs, and poured into the ventricle by the other auricle. This mixture penetrates into the aorta, and through it proceeds in small quantities to the lungs, and hence to the other organs of the body.

The lungs of the adult batrachia have but a few incomplete cells; they receive the blood from two small branches of the aorta, these performing the office of a pulmonary artery. Thus the pulmonary respiration is feeble, but the cutaneous makes up for it by its activity. When the temperature is low it is sufficient to maintain life. Frogs breathe by the action of deglutition, so that to suffocate the frog it is only necessary to hold its mouth open for a time. This mode of breathing is necessitated by the incomplete state of the skeleton of the adult frog; the ribs are wanting, and thus the thorax can no longer be dilated, as in mammals, birds, and ordinary reptiles. Finally, the nervous system in these animals is but little developed; the brain is small, and the cerebellum is scarcely visible.

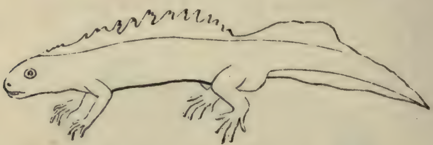

Fig. 380.—Aquatic Salamander (Newt, Eft, or Evvet).

§ 473. Though the class batrachia be not numerous, it has, notwithstanding, been divided into four orders.

The Anoures, which undergo complete metamorphoses, and which in the adult state have no tail; these are the frogs, toads, rainettes, tree frogs, pipas, Surinam toad, &c.

The Urodeles, which preserve the tail, but which in the adult state have four limbs, but no branchiæ: the aquatic salamanders or tritons, are examples of this order (Fig. 380).

The Perenniata, which preserve the branchiæ throughout life, and which also have lungs: these are the proteus, the axolotl (Fig. 369), the menobranchus, and the siren. Finally, the Ceciliæ, which have no limbs, and strongly resemble serpents.

Some very singular animals have been lately discovered, which have branchiæ and lungs like the siren, but which have in place of feet only cylindrical fins, and which so resemble fishes in the whole of their organization, that most zoologists have arranged them in the following class:—these are the lepidosirens (Fig. 146).

CLASS OF FISHES.

§ 474. The fifth and last class of the primary division of vertebrate animals comprises the class fishes. The circumstance of their being destined to live under water strongly affects their whole organization, as is most seen in what regards the apparatus of respiration and circulation; they breathe by gills, and never have lungs* at any period of their lives. Their heart is composed of two cavities, the auricle and ventricle, containing only dark blood; this blood is sent to the gills, and returns from these after being exposed to the oxygen, to be distributed to the various parts of the body, no heart being interposed between the gills and the other organs of the body; their blood is cold, and their skin naked, covered only with scales; they lay eggs, that being their mode of reproduction; and finally, their limbs have the form of fins.

§ 475. They differ considerably in the form of their bodies, but the outline is generally simple: there is no neck, properly so called, and the head is large; their tail is not distinguishable from the rest of the body. Some have no fins, but generally we find them present, arranged in pairs symmetrically at the sides or singly on the back and abdomen (Fig. 381). Those in pairs represent the limbs of vertebrate animals. The anterior are called pectoral fins; the inferior, which vary much in position, are called ventral; the asymmetrical fins are the dorsal (*d*), and (*a*), and caudal (*c*), according as they are placed on the back, under the tail, or at its extremity. They resemble each other in structure, and consist almost always of a fold of skin, supported by osseous or cartilaginous rays, pretty much in the way that the wings of bats and dragons are supported by the fingers and ribs.

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* The swimming bladder seems evidently to form a rudimentary lung.—R. K.

The large openings leading to the gills are placed behind the head; in breathing, the water passing into the mouth is driven across the gills and escapes by these openings. Generally there is but one on each side, and it has a moveable protecting covering; finally, there is throughout the whole length of the body on either side a series of pores, called the lateral line. The skin is sometimes almost naked, but in general is covered with scales; these have occasionally the form of rude grains, sometimes of very large tubercles or plates; but generally they resemble very thin lamellæ, overlapping each other like the tiles of a house, and encased in folds of the skin. They may be compared to our nails, but generally they include much more of the calcareous salts. The colours of fishes astonish by their variety and brilliancy, resembling gold and silver: these depend on a number of small polished plates secreted by the skin.

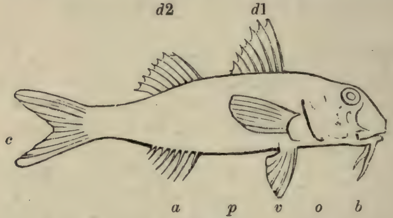

Fig. 381.*

§ 476. The skeleton of fishes is either osseous or cartilaginous: in the lamprey it remains almost membranous, and thus establishes a link between the vertebrata and invertebrata.

§ 477. Their bones have no medullary canal, and when boiled in water they give out no gelatine. The skeleton is composed of a head, trunk, and limbs, with a hyoid apparatus largely developed, and assisting in respiration.

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* The Barbed Mullet (Mullus Barbatus), to show the different fins, &c.:—*p*, pectoral fin; *v*, ventral fin; *d*1, first dorsal; *d*2, second dorsal; *c*, caudal; *a*, anal; *o*, opening leading to the gills; *b*, feelers, or barbs of the lower jaw.

§ 478. The structure of the head is very complex, and composed of many bones; its median portion (Fig. 383) presents behind a cranial cavity (*c*), lodging the organ of hearing as well as the brain. About the middle are the orbital cavities (*or*), and anteriorly, the cavities belonging to the olfactory apparatus (*n*) and a kind of large prominence formed by the vomer, and supporting the upper jaw (Fig. 384 *v*). The analogues of the occipital, temporal, sphenoidal, parietal, frontal, ethmoidal, and vomer may readily be recognised, but most of these parts are composed of several pieces, the original germs of these bones, which never unite in fishes.

Anteriorly, is found the upper jaw, which is sometimes fixed, but more usually very moveable; on each side are an intermaxillary bone (*im*) and a maxillary bone (*m*), which is moveable on the first.

A chain of small bones extends on each side from the anterior angle of the orbit to the posterior, and thus completes the orbital circle. Deeper may be seen on each side a kind of vertical partition suspended to the cranium, and separating the orbits and cheeks from the mouth. It is formed by the analogues of the palatine, pterygoids, tympanics, &c., and articulates

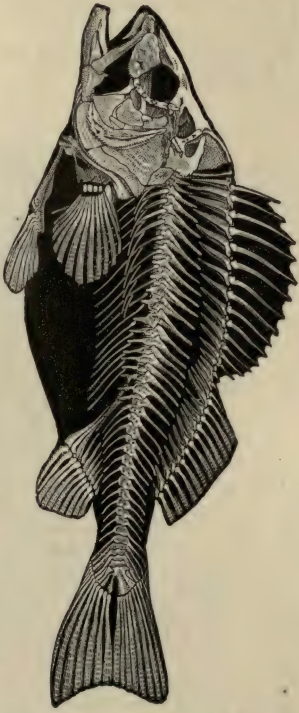
Fig. 382.—Skeleton of the Perch.

with the cranium by two points (on the vomer and temples). Inferiorly it gives attachment to the lower jaw, posteriorly it is prolonged so as to form a moveable covering, called the gill cover. Three bones on each side form the lower jaw, which articulates by a concave surface with the jugal apparatus, just described; finally, an assemblage of bones is found at the bottom of the mouth supporting the gills, and seemingly analogous to the hyoid apparatus (Fig. 384), extremely developed.

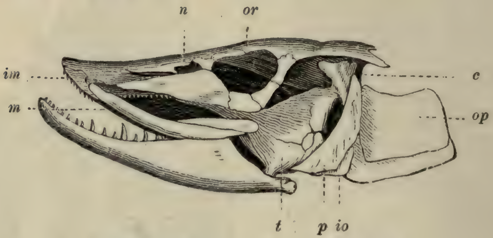

Fig. 383.—Bones of the Head of the Pike.*

The bone of the tongue (*l*) is continued backward with a series of pieces, and articulates on each side with a very long and very large lateral branch (*b*), and this by its opposite extremity is suspended to the lateral partition of the head, already described. These lateral branches, formed of several bones, support inferiorly a series of flattened curved rays (*r*), which assist with the opercular to complete the walls of the branchial cavities; these are the radii branchiostegi. Behind these branches there descend from the median portion of the hyoid apparatus four pairs of osseous arches (*a*), which ultimately are attached to the basis of the cranium by means of some small bones, called superior pharyngeal bones (*ph*); these arches carry the gills, and for this reason are called branchial arches. Still further back, at the entrance of the gullet, are the two inferior pharyngeal bones, so disposed as to be applied against the superior.

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* *c*, cranium or orbit; *n*, nasal fossæ; *im*, intermaxillary bone; *m*, superior maxillary bone; *t*, a kind of lateral partition separating the cheek from the mouth, and which articulates forward with the vomer by means of the palatine arches, above with the cranium (*c*), below with the lower jaw, behind with the pre-operculum (*p*), which, in its turn, supports the operculum (*op*); *io*, the pre-operculum bone, followed by the sub-operculum.

Such generally is the complicated structure of the head of fishes: anomalies exist, as in the sword-fish and in some species allied to the tunny; in these the upper jaw is prolonged into a powerful weapon, with which they attack the largest sea animals. Any further comparison with the osseous head of mammals need not detain us here, for much uncertainty prevails.

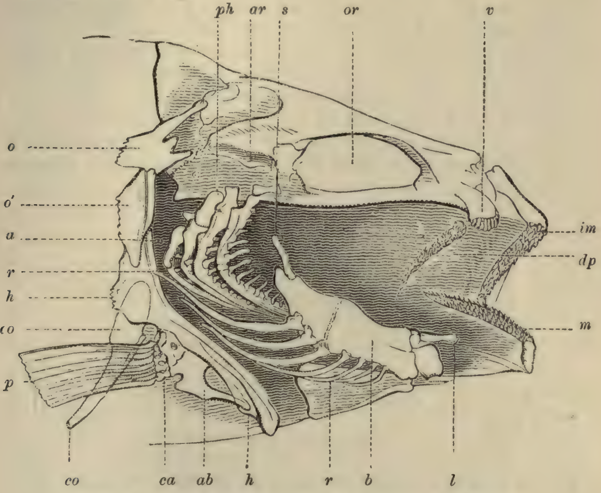

Fig. 384.—Head and Respiratory Apparatus of a Fish.*

§ 479. In the vertebrate column there are but two distinct portions, a dorsal and a caudal (Fig. 382). The body of each vertebra is formed like an hour-glass, with the two extremities hollowed out into conical cavities which sometimes unite by an opening: the double cavities resulting from the juxtaposition of the two vertebræ are filled with a soft elastic substance. The osseous ring formed by the processes of the dorsal part of the column for the protection of the spinal marrow, is repeated beneath the column in its caudal portion; it lodges the great artery of the trunk.

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* Fig. 384. Osseous head of the Perch, partially dissected, so as to show the interior of the mouth and the hyoid apparatus :—*c*, cranium; *or*, orbit; *v*, vomer, armed with teeth; *im*, upper jaw; *dp*, teeth fixed into the palatine arch; *m*, lower maxillary; *l*, lingual bone; *b*, lateral branches of the hyoid apparatus; *s*, stylet serving to suspend these branches to the inner surface of the jugal partitions; *r*, radii branchiostegi; *a*, branchial arches; *ph*, superior pharyngeal bones; *ar*, articular surface of the partition already mentioned; *o* to *h*, osseous girdle supporting the pectoral fin (*p*); *o* and *o′*, scapula, formed of two pieces; *h*, humerus; *ab*, bones of the fore-arm; *ca*, carpal bones; *co*, coracoid bone.

In some the ribs are wanting, in others they are very complete, and surround the trunk; and in some they are connected anteriorly with a chain of bones representing the sternum. The ribs, moreover, often carry one or two small spines, which are directed outwards, and penetrate the flesh. Similar stylets also sometimes proceed from the bodies of the vertebræ; and these are in some very numerous, as in the herring. Finally, in the median line of the body are found the interspinal bones (Fig. 386, *i*); these rest on the spinous processes of the vertebræ, and articulate by the other extremities with the radii of the median fins (*r*); these radii vary much in different fishes: sometimes they are only ossified at the base, formed afterwards of a number of small articulations. These last are called soft or articulated radii; they always form the caudal fin (Fig. 382), and sometimes there are no others.

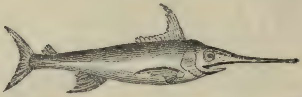

Fig. 385.—Common Swordfish (Xiphias Gladius).

§ 480. The lateral fins, representing the limbs, are terminated by radii similar to the dorsal, and analogous to the fingers; in the pectoral fin, four or five small flat bones (Fig. 384 *ca*) represent the carpus, and these are supported by two flat bones (*ab*), the radius and the ulna. The osseous girdle supporting these is composed of a series of three bones, of which one (*h*) represents the humerus, a second (*o*) the scapula, and a third, composed of two pieces, may be called the coracoid (*co*). The posterior limb (Fig. 382) is less complex; the radii of the ventral fin are supported only on a single bone.

§ 481. In cartilaginous fishes, such as the skate and the shark, the skeleton somewhat resembles that of the tadpole.

The cranium is without sutures, and is composed of a single piece, but modelled and pierced like the cranium of a common fish. The upper jaw is formed of pieces analogous to the palatine bones and to the vomer; the maxillary and intermaxillary bones either do not exist or are merely rudimentary. The lower jaw is also formed of a single piece on each side, and the opercular apparatus is wanting. The vertebral column is often formed of a single tube, pierced on each side for the passage of the nerves, but not divided into distinct vertebræ; and the gelatinous-looking substance acting as a ligament to connect the vertebræ to each other, often forms a continuous cord. The arrangement of the bones of the shoulder, pelvis, and fins, varies. Finally, the hyoid apparatus supporting the gills is arranged pretty much as in other fishes, but in the last of the series, the lampreys, the branchial arches are wanting.

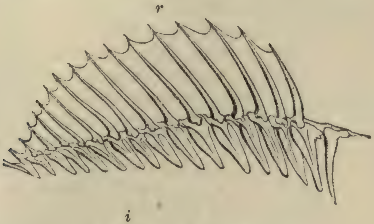

Fig. 386.—Dorsal Fin.

§ 482. Most fish swim with great agility, and it is said that the salmon goes at the rate of twenty-four feet in a second. They swim by alternate flexions of the tail and trunk, and the muscles intended to move these form the greater part of the mass of the body. The lateral fins are not much used in progression, and seem merely intended to maintain the equilibrium of the body, or slightly to modify the direction of its course.

§ 483. A remarkable feature in the organization of some fish is the swimming bladder, placed in the abdomen under the dorsal spine, communicating often with the gullet or stomach by a canal, permitting of the escape of air from its interior; but sometimes no such passage exists, and then it is evident that the air contained in the swimming bladder is a secretion from a gland situated on its walls. By the movement of the ribs, this air bladder is acted on, so that by the quantity of air being diminished, the specific gravity of the fish alters according to circumstances; but fish swimming near the bottom have no air bladder—such as the skate, sole, turbot, and eel; and sometimes this bladder is membranous and vascular, so as to resemble a lung.

In a small number of fishes, as the flying fish, the pectoral fins are much extended, so as to permit the animal to leave the waters and to fly to a considerable distance; and some by the same means travel on the land, and even climb up trees.

Whilst speaking of the organs of motion in fishes, we cannot omit mentioning a singular apparatus which some of these animals have, by means of which they adhere strongly to a foreign body: it is a flattened disc covering the top of the head, composed of cartilaginous plates, moveable, and directed obliquely backwards (Fig. 387). Fishes of the genus echeneis are the only ones which have this kind of organization, and the species found in the Mediterranean has been long celebrated under the name of remora (Fig. 388). Its natural history has been overloaded with fables, and the power of suddenly arresting a ship in its course was ascribed to it. A species closely resembling the preceding is very common in the waters around the Isle of France, and it is said that on the coast of Caffraria it is employed in fishing for other fishes. A line being attached to its tail it is launched in pursuit of others; so soon as it becomes attached to them the fisherman, by means of the string, gains possession of both.

§ 484. The life of a fish is occupied almost wholly in providing for its subsistence and escaping its enemies; its senses and faculties seem obtuse and limited; it exercises no known industry, and seems to be without any remarkable instinct; its brain is small, and the organs of sense imperfect. The brain does not fill the cavity of the cranium, there being found within it a spongy fatty mass, particularly in the adult specimen. The lobes composing the brain are placed in a file, one pair behind another,—namely, the olfactory lobes, the hemispheres, the optic lobes, and the little brain, and behind that the lobes belonging to the medulla oblongata. The sense of touch seems to be exercised only by their lips and by the feelers surrounding the mouth (Fig. 381 *b*); their taste must be imperfect, considering the structure of the tongue; and as the nasal fossæ consist of cavities which are traversed neither by air nor water mixed with air, the power of smell cannot be acute. The organ of hearing is enclosed within the cavity of the cranium, and is composed of a vestibule and three semicircular canals, which sounds can only reach by vibrations of the common integuments and bones of the cranium. The eyes, it is true, are large, but not very moveable, the iris is not contractile, and the lens is spherical; they have neither eyelids nor lachrymal apparatus. In some flat fishes—as the sole, plaice, turbot—both eyes are placed on one side of the head, and this want of symmetry extends to other parts of the body.

§ 485. Fishes are very voracious: a very few only live chiefly on vegetables; and they are indiscriminate as to their food. Some species have no teeth; but in most there exist several rows, as in the shark (Fig. 390); we find them, indeed, attached to several bones with which they unite, for they have no roots; they are shed at regular intervals and replaced by new teeth, and being generally all of one kind they receive their names from the bones which carry them, as palatine, vomerine, maxillary, &c. But in different species they vary very much in form, being sometimes so fine and thickly set as to resemble the pile of velvet, in others they are strong robust hooks, rounded tubercles, or sharp cutting plates.

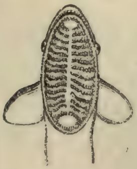

Fig. 387.—Dorsal fin of the Remora.

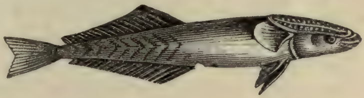

Fig. 388.—Remora; Sucking Fish.

§ 486. Some, as the lamprey, live by suction, nevertheless they also have teeth. There is no salivary apparatus, and the gullet is short, the liver large and soft, and the pancreas is replaced by the pancreatic cæca surrounding the pylorus; finally, the position of the extremity of the gut varies much; the kidneys are extremely large, extending on both sides of the vertebral column, and nearly throughout its whole length.

Their excretory ducts terminate in a kind of bladder, the external orifice of which is situated immediately behind the anus and the orifice of the reproductory organs.

Digestion seems to be performed rapidly, and the chyle is absorbed by numerous lymphatic vessels which terminate by several trunks in the venous system near the heart.

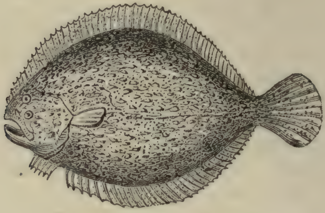

Fig. 389.—The Turbot.

§ 487. The blood of fishes is red, and the globules are elliptic, and of considerable size (§ 81, Fig. 37 *c*). The heart (Fig. 52) is placed under the throat, in a cavity separated from the abdomen by a kind of diaphragm protected by the pharyngeal bones, the branchial arches, and the humeral girdle. It is composed of an auricle and ventricle, from which springs the pulmonary artery. This vessel is enlarged into a contractile bulb at its commencement; it soon divides into branches, which proceed to the gills; and the blood, after having traversed these organs, returns towards the heart by another vessel, also passing along the edge of the branchial

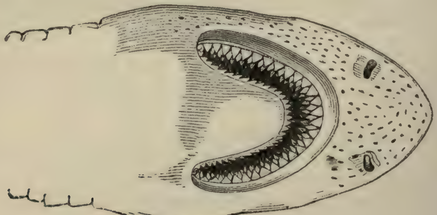

Fig. 390.—Head of the Shark.

arches. There these canals send some branches to the neighbouring parts, and reunite to form a large dorsal artery, which proceeds backwards under the vertebral column, and gives branches to all parts of the body (Fig. 52). Finally, all the venous blood does not pass directly to the sinus (auricle) already mentioned; that from the intestines and from some other parts, before returning to the heart, circulates in the liver by the vena portæ.*

Thus it is that the heart of fishes corresponds to the right or anterior heart of hot-blooded animals, and the blood passes only once through the heart. The circulation must be slower than in them; nevertheless, the pulmonary (branchial) circulation is complete (Fig. 49).

§ 488. Respiration is performed in fishes by means of the air dissolved in the water, which entering by the mouth is passed across the gills or branchiæ. These are vascular laminæ, supported by the osseous branchial arches already described. Four branchiæ generally exist on each side. In most cartilaginous fishes there are five, and in the lamprey seven. In nearly all the osseous fishes these lamellæ are simple, and are fixed only by the base; but in a small number, such as the hippocampi, commonly called *sea-horses* (Fig. 391), they are, on the contrary, ramified, and have the form of bunches of feathers; finally, in most cartilaginous fishes, as in the skate and shark, they are attached by their external edge to the skin, as well as by their internal to the branchial arches.

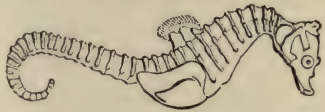

Fig. 391.—Hippocampus or Sea Horse.

The mechanism of breathing is best observed in the living fish: the mouth and gill-covers open alternately; the water entering by the mouth escapes by the openings of the gills, the gills themselves having in the meantime been bathed in it; whilst this happens, the oxygen is extracted from the water. In osseous fishes there is generally but one aperture of the gills on either side: in those with fixed gills, there are as many apertures as branchiæ. Thus, in the shark (Fig. 392) there are five pairs of openings, and in the lamprey (Fig. 409) seven. Hence the nature of the respiratory apparatus may be known by an inspection of the exterior. Finally, in some fishes (the lamprey), the water entering by the mouth reaches the gills through a kind of canal placed under the gullet, and interposed between the cavity of the mouth and that for the gills; the arrangement resembles in some measure the trachea of the higher organized animals.

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* As in mammals, birds, &c.—R. K.

Fishes do not consume much oxygen; nevertheless, some come to the surface from time to time to breathe air, as if that absorbed by the gills was not sufficient. Some even swallow it, and convert the oxygen into carbonic acid whilst passing through the intestines; the loach of still waters presents this singular phenomenon. When removed from water into the air, most fishes speedily become asphyxiated, not from the absence of oxygen, but because the branchial laminæ, no longer floating in water, collapse, and exclude the access of air; they also dry up, and become unfit for the exercise of their functions. The larger the external aperture of the gills, the speedier does death ensue.

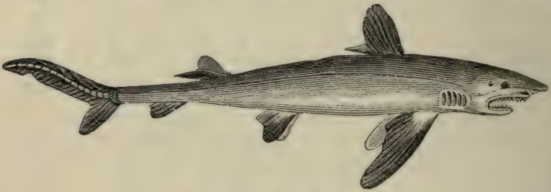

Fig. 392.—The Shark.

The family with labyrinthiform pharyngeals* have receptacles in which they can preserve water, as in reservoirs, to moisten the branchiæ: these receptacles are water-collecting cells placed above the branchiæ; hence the name of the family.

These cells (Fig. 393), enclosed under the gill-cover, and formed by the lamellæ of the pharyngeal bones, retain a certain quantity of water, and thus allow the animal to live a long time in the air. They leave the rivers and stagnant waters in which they live to traverse tracts of land, and some even are enabled to climb trees, as the anabas. They are natives of the Indies, China, and the Moluccas; and one species, the gourami, much esteemed, has been acclimated in the ponds of the Isle of France and Cayenne.

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* Examples: *anabas scandens*, climbing fish; *osphromenus olfax*, the gourami.—R. K.

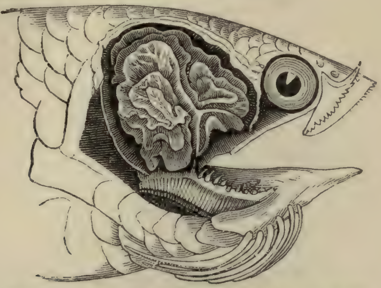

Fig. 393.—Respiratory Apparatus of the Anabas, or Climbing Fish.

§ 489. A remarkable production of fishes is that of electricity, and the power it gives them of killing their prey by an electric shock. The torpedo, the silurus or malapterurus, and a species of gymnotus have this power; and what is very remarkable is, that the electric organ presents a different conformation in each.

The gymnotus, or electric eel of Surinam (Fig. 394), possesses the power in the highest degree; it resembles an eel, but it has no fins towards the extremity of the tail, and it has no distinctly visible scales. It attains sometimes six feet in length, and the skin is covered with a gluey matter. It is met with in vast numbers in the rivulets and stagnant waters of the immense plains of South America. The electric shocks, which it discharges at will, are sufficiently strong to kill men and horses; and being transmissible through water, the gymnotus does not require to touch its prey. At first the electric discharges are feeble, but when roused they become terrible; but by this effort it becomes exhausted, and requires repose before it can renew the attack; this is the moment its captors avail themselves of to seize it.

Wild horses are driven into the waters inhabited by these fishes, and on these the gymnoti expend the first shocks; being thus exhausted, they are easily taken by the net or harpoon. The electric organs of the gymnotus are arranged along the back and tail in four longitudinal fasciculi, composed of a great number of parallel membraniform plates, which are nearly horizontal, and united by an infinity of other still smaller plates,* placed vertically across; these small prismatic and transverse cells formed by the reunion of these laminæ are filled with a gelatinous matter, and the apparatus receives numerous very large nerves.

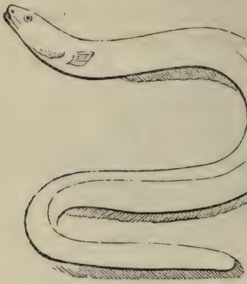

Fig. 394.—The Gymnotus Electricus; Electric Eel of Surinam.

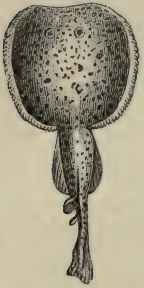

Fig. 395.—The Common Torpedo.

The torpedo (Fig. 395), is a cartilaginous fish, resembling the skate. Its body is smooth, and represents a disc nearly circular, the anterior edge of which is formed by two prolongations of the muzzle, which on each side proceed to unite with the pectoral fins, and leave between these organs, the head, and the branchiæ, an oval space, in which is lodged the electric apparatus of the fish. This apparatus (Fig. 396) is composed of a number of vertical membranous tubes closely packed like honeycomb, and subdivided by horizontal partitions filled with mucosities, and animated by several very large branches of the pneumogastric nerve. In these singular organs is produced the electricity, which has now been proved to resemble in every respect common electricity. These animals are less powerful than the gymnotus. By experiment, it has been ascertained that this property depends on the posterior lobe of the encephalon, and that by destroying this lobe, or cutting the nerves proceeding from it, the faculty is lost. They are found in the seas on the coast of La Vendée and Provence.*

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* I have counted 240 of these plates in the inch.—R. K.

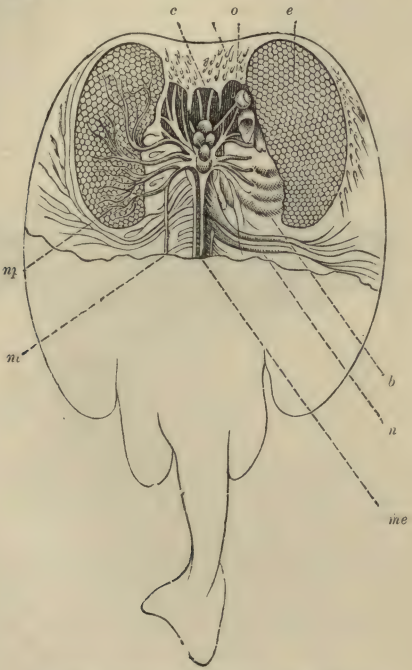

Fig. 396.—Electric Apparatus of the Torpedo.†

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* The Romans were well acquainted with the electric properties of the Torpedo, and used them for the cure of paralysis.—R. K.

† *c*, the brain; *me*, spinal marrow; *o*, eye and optic nerve; *e*, electric

Finally, the silurus electricus or malapterurus (Fig. 397), is a native of the Nile and the Senegal: its length varies from a foot to fifteen inches, and its electric properties seem to reside in a particular space, situated between the skin of the flanks and the muscles, resembling a leafed cellular tissue. The Arabs call it the *raasch,* which signifies thunder.

§ 490. Fishes multiply by means of eggs, and a single spawning in some produces hundreds of thousands. In general they have only a mucilaginous protecting envelope, and they are hatched after spawning without any care on the part of the parent. But some are ovoviviparous. However this may be, they are all abandoned by their parents, and many perish. It is probably owing to the circumstances connected with the birth, that fishes are found in vast troops, called by the fishermen *bancs.* These reunions can scarcely be called societies, and they probably follow each other from a tendency to imitation.

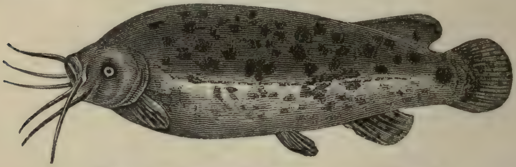

Fig. 397.—Electric Malapterurus of Africa.

§ 491. However this may be, these animals unite in vast troops to ascend rivers or to change their *habitat.* Some lead a sedentary life, remaining always in the same locality; others are constantly wandering, and some perform distant voyages. At fixed periods of the year they assemble in vast numbers from regions which, if not distant, are at least unknown. This is the case with the herring, and the same may be said of the salmon. The herrings deposit their eggs near the coast, and the young retire, in all probability, merely into deeper waters. The idea of their travelling to and from the Arctic Seas seems quite a fable. They appear on the coast in winter and in early spring, and again at midsummer and during the autumn. Their numbers when they first appear seem incredible; but they are capricious, and will abandon

organs; *np,* pneumogastric nerves proceeding to the electric organs; *nl,* a branch of the preceding forming the lateral nerve; *n,* spinal nerves.

certain waters for a long period. From the middle of October to the end of the year they abound in the part of the sea called La Manche (the English Channel), and principally in the Straits of Dover, as far as the mouth of the Seine. In July and August they are generally found in the open sea, at a distance from the coast, and the spawn has been found at every season of the year. After spawning, they are poor and of little value. Sixty thousand eggs have been found in a single female of a medium size. In conclusion, but little is known of the natural history of the young of these fishes.*

§ 492. The sardine, mackerel, herring, and anchovy are fish of passage, or migratory, which periodically visit our shores and give rise to important fisheries. The salmon is also equally remarkable for its journeys or voyages. It inhabits all the Arctic Seas, and each spring it enters the rivers in vast troops, to ascend them even to their sources. In these emigrations the salmon follow a regular order, forming two long files, reunited in front, conducted by the largest female, which precedes, whilst the small males form the rear-guard. These troops swim in general with much noise, in the middle of rivers, and near the surface of the water if the temperature be mild, but nearer the bottom if the heat be great. In general, salmon advance slowly, sporting as they proceed: but if danger appears to threaten them, the rapidity of their course becomes such that the eye can scarcely follow them. If a dyke or cascade opposes their progress, they make the greatest efforts to overcome it. Resting on some rock, and extending the body suddenly and with violence, after being curved, they spring out of the water, leaping occa-

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* The herring fishery was formerly, especially with the Dutch, a branch of industry of great national importance; and in the two provinces of Holland Proper and West Friesland, two thousand vessels and more than eight hundred thousand people were engaged in this fishery. Although much diminished in importance everywhere, the various ports between Dunkirk and the mouth of the Seine still employ from three to four hundred vessels and about five thousand seamen in this fishery, and the products have been valued at nearly four millions of francs.

It is a net fishery, the nets being suspended in the sea like a wall: into the meshes, which must be of a legal size, the herring enters head foremost beyond the gill covers, and is thus caught between the gill covers and the pectoral fin. If intended for salting, it should be done as soon as possible. By the old Dutch laws, no herring was allowed to be salted after sunset. The Dutch still maintain their superiority in the curing of herrings.†

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† The pilchard, still caught in great numbers on the coast of Cornwall, is a fish analogous in its habits to the herring.—R. K.

sionally to the height of four or five metres (fifteen feet) in the air, and so as to fall beyond the obstacle which stops them. Salmon ascend rivers even to their source, and search in the small streams and tranquil places a bottom of sand and gravel adapted for the deposition of their eggs. Then, feeble and thin by such fatigue, they descend in autumn towards the mouth of the rivers, in order to pass their winter in the sea. The eggs are deposited in a trough dug by the female in the sand; they are afterwards fecundated by the male. The young salmon grow very rapidly; and when they are about a foot long, they leave the rivers to repair to the sea, which they quit in its turn to again enter the rivers, when they are about four or five decimetres in length (from sixteen to twenty inches), that is to say, towards the middle of the summer that followed their birth. We have already seen that the swallows, which at the approach of the cold season emigrate to the south, return annually to the same places. It appears that salmon have the same instinct. To be assured of it a naturalist of the name of Deslandes put a copper ring in the tail of twelve of these fishes, and restored them to liberty in the river Auzou, in Brittany. Soon afterwards they all disappeared, but the year following they caught in the same place five of these salmon; in the second year three, and in the year following still three.

[The history of the Scottish salmon, which I have investigated with much care, differs in many essential points from that given in the text by my friend, the author. The precise *habitat* of the salmon whilst in the ocean is unknown ; but at stated periods it ascends the rivers even to their sources, in general during the autumn and early winter months. Under the gravel of these fresh-water streams it deposits its eggs, which in early spring, usually about the beginning of May, leave the gravel to pass into the stream. The period intervening between their escape through the gravel to their descent to the ocean as *smolts* (that is, young fish covered with silvery scales), has not yet been fully determined, some viewing it as a year, others only a few weeks. One thing is certain ; when the ova or eggs of the salmon have been removed from the salmon artificially and deposited under the gravel of an artificial pond in October or November, the young are found to ascend through the gravel in the waters of the pond in April of the following year, and at that time are about an inch in length. If detained in the pond they grow but little ; nevertheless, in the month of May of the year following their ascent through the gravel they undergo the metamorphosis into *smolts*, that is, they lose most of their generic characters, and becoming covered with silvery scales, descend the fresh-water streams to the ocean. It has been proved, experimentally, that these smolts, which measure when they leave the pond for the ocean only four or five inches, return to the rivers, in five or six weeks, well grown fishes of five or even six pounds weight. Such is the effect of their residence in the sea even for a few weeks. But what is remarkable is that all the fry do not leave the pond at the same time, though of the same size and age. A full half remain, from causes unknown, and only descend to the sea the following year. The cause of these anomalies, and even the residence of the fry for a year in the fresh-water ponds, I am inclined to ascribe to their being placed in an unnatural position; confined and cribbed, and so stunted in their growth and development. Thus certain interesting questions in the history of the salmon still remain unsolved: the first of these is the period passed in the running stream, its natural habitat for the time from the moment when it passes through the gravel (in April) to its descent to the ocean as a smolt: experiments made in artificial ponds cannot decide a question of this kind. Second, when young salmon are detained in ponds, a certain number only leave the ponds after the second year of their residence in such waters; what becomes of these? Third, what is the true nature of the smolt, first called par, which frequents at all seasons the rivers from near their sources to the estuaries in which they terminate; which so closely resembles the young of the salmon before it assumes its silvery scales; which is male and female in nearly equal numbers, but in which the ova of the female are never developed, whilst the milt of the male is found developed nearly at every season of the year.—R. K.]

§ 493. The habits of fishes do not offer many curious particulars; nevertheless, reflecting on their importance but a few years ago in the history of the maritime nations of Europe, and that in France there are from thirty to forty thousand seafaring men still engaged in this branch of industry, extending their voyages to the coasts of Iceland and Newfoundland in quest of the cod (Fig. 398), a large and excellent fish abounding on these coasts, though not on ours, the subject cannot be said to be without interest.

§ 494. *Classification.*—Fishes form one of the most numerous classes of the animal kingdom, and are usually divided into two series, according to the nature of their skeleton.

The group or sub-class of osseous fishes is by far the most numerous in genera and species. It is composed of all the ordinary fishes, and is subdivided into six orders by characters in general not very important. These orders are—Acanthopterygii, Malacopterygii abdominales, Malacopterygii sub-branchiales, Malacopterygii apodes, Lophobranchii, and Plectognathi.

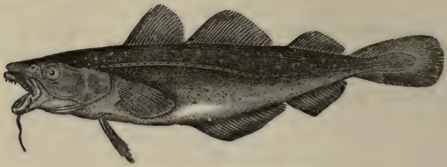

Fig. 398.—Common Cod.

§ 495. The plectognathi differ from all other fishes in the conformation of their mouth, for in them the upper jaw-bone is united to the cranium. This family comprises the coffres (Fig. 399), which have the body covered with a kind of cuirass with osseous compartments; the diodon or globe-fish, and the tetrodon, which by swallowing the air become inflated like a ball, are examples of this class.

§ 496. The lophobranchii are characterized by the structure of the gills. These, instead of resembling the teeth of a comb, divide into little rounded tufts, fixed in pairs along the branchial arches. The syngnathus and the hippocampus belong to this family.

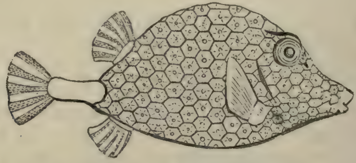

Fig. 399.—Trunk Fish (Ostracion).

§ 497. The acanthopterygii comprise all osseous fishes with the upper jaw moveable and comb-formed branchiæ, and in whom the first fin is supported by osseous and spiniform rings (Fig. 386). The perch, the mackerel, the tunny (Fig. 400), the sword-fish, and nearly three-fourths of all known fishes belong to this family.

§ 498. The abdominal malacopterygii are distinguished from the preceding by having the rays of the first dorsal fin cartilaginous, articulated towards the extremity, and generally divided into several branches (Fig. 301). This character is common to it with the two remaining groups of osseous fishes, and to distinguish them it is necessary to add, that the ventral fins are situated under the abdomen, behind the pectoral fins, and not attached to the bones of the shoulder. To this order belong the carp, the pike (Fig. 402), the silurus (Fig. 397), the salmon, the herring, the sardine, and the anchovy.

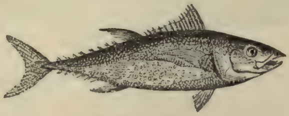

Fig. 400.—Tunny.

§ 499. The sub-branchiated malacopterygii have the fins formed in the same manner as in the last; but their abdominal fins are placed under the pectorals. This division comprises the cod (Fig. 398), the whiting, the remora (Fig. 388), and the the family of the pleuronectidæ, or flat fish, as the plaice (Fig. 404), the turbot (Fig. 389), the sole, &c.

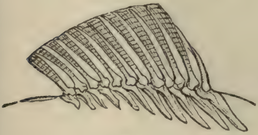

Fig. 401.

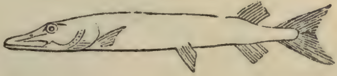

Fig. 402.—Pike.

§ 500. Finally, the malacopterygii apodes are characterized by the absence of ventral fins, and of spinous rays in the dorsal fin. To this family belong the eels, the gymnotus (Fig. 394), &c.

§ 501. The cartilaginous fishes, or chondropterygii, have the skeleton cartilaginous, and sometimes almost membranous, never osseous, the calcareous matter hardening its surface being deposited in little grains. There is even a resemblance between it and that of the tadpole. The superior maxillary and intermaxillary bones are rudimentary, and the upper jaw is formed essentially by the palatine bones. Sometimes the gills are free at their edge, and sometimes fixed, and this difference serves as a basis for their division into two groups, —namely, the chondropterygii with free branchiæ, and those with fixed branchiæ; and these latter are subdivided into two others, the *selaciens* and the *cyclostomes.*

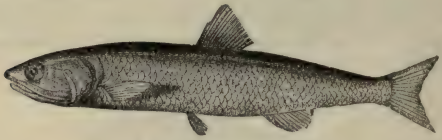

Fig. 403.—The Anchovy.

§ 502. The order of chondropterygii with free gills are also called *sturiones*, because they have for their type the sturgeon (*sturio*). It is composed of fishes in whose figure there is nothing irregular (Fig. 405), and which have for the most part the skin provided with large osseous plates disposed in rows,* and the mouth toothless.

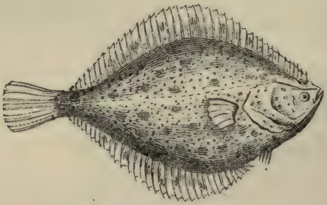

Fig. 404.—The Plaice.

§ 503. The chondropterygii with fixed gills have a remarkable common character, which has already been described. The gills are fixed at both edges, and instead of having one opening by which the water escapes, there are several,—as many openings, in fact, as there are intervals between the gills. The openings are almost always external, nevertheless they terminate sometimes in a common canal, by which they transmit the water externally; finally, cartilaginous arches suspended in the flesh are often found opposite the external edges of the branchiæ. Lastly, these fishes differ much from each other, and constitute two orders —the selacian (plagiostomi) and the cyclostomi.

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* In other words, a dermoid skeleton.—R. K.

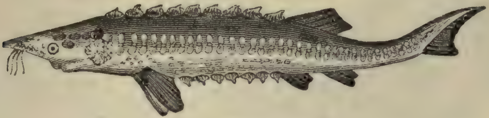

Fig. 405.—The Sturgeon.

§ 504. The first, including the family of the squali, composed of the sharks properly so called, the requin (Fig. 392), the hammer-headed shark (Fig. 407), the saw-fish, &c.; and the family of the skate, in which the torpedo (Fig. 395) as well as the skate properly so called have a place (Fig. 406). All these fishes have five branchial openings on each side of the neck, resembling fissures; and several have on the upper part of the head two openings, called blow-holes, by which the water reaches the gills when the throat is temporarily filled with their prey. They are most voracious animals, especially the requin or blue shark (Fig. 392). Some are oviparous, whilst others lay eggs covered with a hard and horny case.

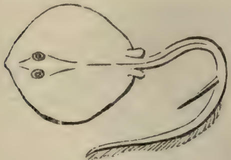

Fig. 406.—Skate.

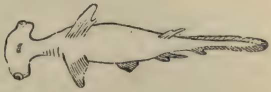

Fig. 407.—Hammer-headed Shark.

§ 505. The order of cyclostomes is characterized by the singular conformation of the mouth, adapted only for suction (Fig. 408); they are the most imperfect of all the ordinary vertebrata. Their skeleton is sometimes membranous, as in the ammocœtes or river lampreys, and is always less complex than in other fishes; their nervous system is but little developed, and the gills have the form of small bags.

The lampreys (Fig. 409) constitute the principal type of this group.

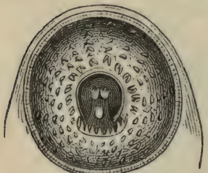

Fig. 408.—Mouth of the Lamprey.

§ 506. A very singular animal, evidently belonging to the vertebrata, but deficient in many of their characters, has lately attracted some attention. It is called the amphioxus, and is a small marine animal, sufficiently like a fish, but which has neither vertebræ properly so called, nor heart, nor red blood, nor a distinct brain. Its skeleton is represented by a cartilaginous stalk, resembling the cartilaginous cord preceding the formation of the vertebral column in the embryo of the ordinary vertebrata; the cerebro-spinal axis occupies its usual place, but presents anteriorly no enlargement which may be compared to a brain; the circulation is accomplished by means of vessels whose walls are contractile, and the walls

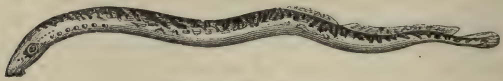

Fig. 409.—The Lamprey.

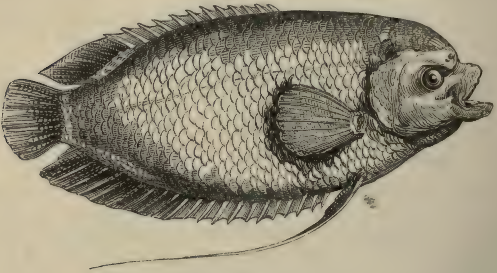

Fig. 410.—The Gourami.*

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* A valuable fish, now being acclimatized in France; it comes originally from China and some Asiatic rivers. It was first introduced into the Isle of France.—R. K.

of the pharyngeal cavity take the place of a respiratory apparatus. Most zoologist arrange this degraded vertebral animal in the class fishes; but it seems evident to us, that in a natural classification the amphioxus ought to occupy a particular division.

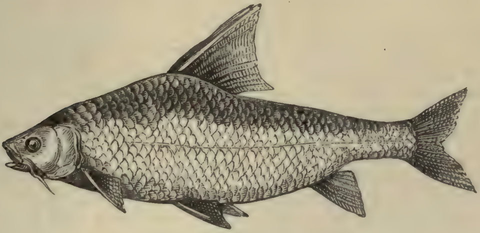

Fig. 411.—The Binny.*

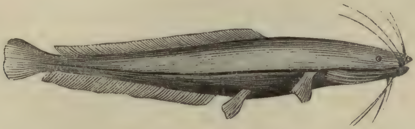

Fig. 412.—The Flathead.†

[It formed no part of the plan of the author's excellent work to follow out any of the great views which the introduction of the transcendental anatomy into science has forced on the consideration of all observers, and I have therefore not deemed it necessary to add largely to the few hints given by the author himself. As in a passage or two of the preceding portions of the work the author has glanced at a subject of great interest, namely, the distinctness of species, and even of genera, yet strongly resembling each other in different regions of the globe, I have thought that the following brief sketch of the relation of species to genus might interest the reader :—

"Zoology, to be esteemed a science, must be based on philosophical principles. True, it is a science of observation, and not of calculation ; it has to deal with living bodies, and with the mysterious and hitherto undiscovered principle of life, whose laws are not to be explained by numbers, however multiplied, nor by a geometry, however refined. Fluxions avail not here, nor the integral calculus. Nevertheless, some great minds have shown that Zoology has its laws, which, despite difficulties almost innumerable, may be so inquired into as to evolve some truths of more import to man than at first appears.

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* Barbus Binny: Cyprinus Binny. It is extremely common in the Nile, and very good to eat. Its qualities as an article of food have given rise to the following Egyptian proverb—"If you know of any better than I am, do not eat me."—R. K.

† Flathead: from a drawing by Mr. Burchell. It inhabits the waters of the Great Orange River in South Africa.—R. K.

"The observation of nature is no doubt the first duty of every candid observer ; next comes the duty of the inquirer into her laws, for the mere observance of a fact is of no value whatever, unless that fact be placed in its relations with all others. Men had observed, and no doubt observed carefully, long before the age of Aristotle, but he alone was equal to the production of the *Historia Animalium.* He was followed, at a long interval, by Buffon and Linné ; last came the immortal Cuvier. The discovery of the true signification of the fossil remains of the organic world by this illustrious and justly celebrated man was unquestionably the most remarkable step ever made for the advancement of the human mind. The element of research he employed was the descriptive anatomy of the adult or fully-developed individual of all, or at least of most, of the species of animals now occupying the globe. The minute descriptive anatomy of the species, with a view to the rigorous determination of its true nature and position in a natural-history arrangement, seemed to be the ultimatum of all his inquiries ; and if he spoke of genera or natural families, it was more as a naturalist, or as one by whom generic distinctions were viewed rather as expressions of philosophic arrangement than as realities based in Nature. It was whilst pursuing this inquiry into the existing and living fauna of the present world, that the thought struck him of applying the element of research he then wielded with such dexterity to the fossil remains of a former world : never since man studied science had a thought so fruitful in great results entered the human mind. By it he dissected, as it were, the globe itself, giving to the lovers of truth in science a key wherewith to read those vestiges of successive animal forms which we, for want of a more correct term, call Vestiges of Creation, and removed from the mental vision of men that dark veil of ignorance which had certainly endured for some thousand years.

"As Cuvier pursued his anatomical investigations, for they were strictly so, he classified and arranged the individual animals examined by him into distinct species, according to their anatomical differences ; still, adhering to the anatomical method, he only viewed the distinctions as generic when they were wider, larger, and quite apparent. Not that he despised external characters, or neglected them; but as an anatomist he felt himself bound to view them as secondary, and of infinitely less importance than the anatomical. Moreover, they were wholly inapplicable, or nearly so, to the fossil world, at least to that class, the Vertebrata, in which man is most interested.

"If the theory I am about to propose be true, that the young, namely, of every species, represents a *generic animal*, embracing in its structure and natural history characters the *possible* of all the species, past, present, and to come, belonging to the natural family of which it forms a portion, then the natural history of the fossil world might be guessed at, might be restored, but not otherwise. The fossil horse was only a horse *generically;* but whether a horse properly so called, an ass, a zebra, a quagga, or none of these, none can now for certain say: the fossil tiger was no tiger, in all probability; nor the bear a bear, appertaining to, or to be classed with, any species now living. The exterior of the fossil world is lost for ever; all that is left of it being merely the fabulous traditions of rude ages, peopling the world with monsters, which the discoveries of Cuvier in some measure corroborated.

"When the anatomical method failed in Cuvier's hands, as it often did, the illustrious discoverer was thrown upon the field of hypothesis. The seeming fixity of species was the first stumbling-block he encountered; this led to his theory of successive creations, if that can be called a theory which removes the inquiry at once from all further investigation. By anatomy it was not easy, occasionally impossible, to distinguish species from each other, which, when viewed as clothed with their external attributes, are obviously and notoriously distinct. In this predicament stood the lion and tiger, panther and leopard, horse, zebra, ass, dog, wolf, fox, jackal, pig, ox, man. The theory of variety, to a certain extent permanent, was next brought to bear on these difficult questions; the influence of domesticity was also invoked, and even the fruitfulness of hybrid races was asserted; so that Natural History fast retrograded towards the silly hypothesis ascribed to Aristotle, who is supposed to have conjectured that the vast variety of animal forms with which Africa abounds is due to the arid nature of the country, and its paucity of rivers and springs, thus bringing together animals of many species and genera; hence the varied character of Afric's fauna.

"The inadequacy of anatomy to distinguish species in every case was fully admitted by Cuvier himself. I also admit this practically, but with this reservation, that the minute anatomy of even the osteology of every species differs in a certain degree, however slight, from every other; but such minute differences are not of much importance in the establishment of important principles, nor can they always be depended on. The nasal bones of the horse and ass differ in form from each other, more perhaps than any part of their respective osteology; but how insignificant is this difference, in a natural-history point of view, when compared with those external characters which mark the zebra, the horse, the ass, and quagga! The same remarks apply to the lion and tiger, in respect of these very bones, the nasal, and their relations to the superior maxillary bones, to the white ox of Scotland, and to the common domestic ox. The nasal bones, the skeleton of the head, the character of the teeth, do not differ more regularly or constantly, nor to the same extent, in the horse, zebra, and ass, than they do in the races of man. The skeleton of the head of the negro and Bosjesman differs much more widely from the white races of man than those of the horse and lion differ from the corresponding structures in the tiger and zebra. I do not, therefore, admit, to the full extent, that anatomical characters ever fail to discriminate species; but I freely admit their occasional inadequacy to characterize or to lead to the determination of species in a practical sense. On the other hand, the facility with which this may be done, by a consideration of the external characters, is known to all the world. Science admits of no exaggeration; Anatomy has done much for Natural History; much for Philosophy; still more for humanity, by purging the human mind of deep-rooted errors, of a gross and scandalous character, of forty centuries' growth. But Anatomy has its limits, notwithstanding, and these limits were admitted and defined by the Great Master himself.

"It was not to be expected that a mine of knowledge such as was discovered and first worked by the great Cuvier, should continue to be explored by so many vigorous hands, and that all should go smoothly with the labourers: difficulties soon appeared, and they increased so rapidly in number and in strength, as to cloud with anxiety for the fate of his great discovery the mind of the immortal author of the *Ossemens Fossiles.* It seemed as if he were about to survive his own vast reputation. So seemingly unimportant a question as the influence of domestication over animal life embarrassed the great anatomist. The anatomical element of inquiry having failed in establishing specific distinctions in the various oxen which ornament the cultivated earth, Cuvier was forced to imagine them to be like the dog, of one species; Goethe, the transcendentalist, starting from a higher point of view, had arrived at the same conclusion. 'The infinite varieties of the domestic ox,' observed the sublime author of *Faust*, 'are simply the gift to man of domesticity acting through millions of years.' Such also was Cuvier's opinion, omitting the 'millions of years.' What his real opinions were on the influence of time and circumstances he never, so far as I know, communicated to any one. The monumental records of Egypt, depicting man then as he is now, after the lapse of at least four thousand years, were perfectly well known to him. Still greater difficulties he prudently passed by, without a passing notice. And yet his great discovery laid the foundation of Geology, Palæontology, and a true history of life on the globe. Before him these sciences could not be said to exist.

"Prior to this eventful scientific era, the German school of philosophic anatomists had made an advance towards the same object, but from a different point of view. Anatomy was still the element of research which they employed, but it was the anatomy of the embryo. At the head of this school was the justly-celebrated Goethe,—poet, philosopher, naturalist, mathematician; his genius seemed universal. He it was who first distinctly formuled the law of unity of the organization in all that lives or has lived. The doctrine of 'arrest of development' came soon after into vogue, chiefly through Meckel and the German schools of anatomists,—a doctrine based on a superficial and a somewhat incorrect application of facts, curious and important in themselves; to this at last were added the Teratologie of Etienne Geoffroy St. Hilaire and the serial unity of De Blainville.

"Believing the transcendental in Anatomy to be the only instrument of research at present known by which a correct basis can be laid for the philosophy of Zoology, I have never ceased to study and teach it since the period (1811) when it first became known to me. To the writings of Vicq. d'Azyr I am indebted for the first hints of its existence. Biassed in favour of descriptive anatomy, I have ever objected to the too hasty adoption of extreme transcendental views, holding it to be a true maxim in science, as well as in social life, that the change in step or advance, in order to be certain and trustworthy, must ever be made with caution, and, if possible, supported by the demonstration of physical materials; or, in other words, the thought which genius submits to the world as an idea must become a physical demonstration before the world can fairly be called on to admit its truth. This is the view I take in the following Memoirs,* in some of which it is my intention to apply the transcendental to Natural History, as a preliminary to my inquiry into the natural history of man. The true relation of species or race to genus or natural family seemed to me to present a favourable mode of testing the value of the transcendental, not with any idea of testing its truth,—that has been settled long ago,—but of ascertaining its practical value as an instrument of research. The true relation of race to natural family being first discovered, it will then be time enough to apply the transcendental to the relation presumed to subsist between natural families, and, lastly, between these and the universal primæval life of the organic world of this globe.

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* Published in the *Zoologist*. Van Voorst. London.

"In selecting the natural family of the Salmonidæ as a subject of research, I have been guided by several considerations : I had already made them the subject of extended research, and their external characters offered favourable points of view for such an inquiry. It is chiefly to the exterior that I give my attention in the present Memoirs ; the interior will follow. I commenced with the dentition, that natural-history character to which all, whether naturalists or anatomists, ascribe such importance ; next followed a brief inquiry into the systems of coloration and proportion. To all these the transcendental applies, or ought to apply, if true. That it is true as a theory I have not a doubt myself, however I may fail in proving it to the satisfaction of others. My immediate object is to prove the existence of a *generic animal*, the product, no doubt, of hereditary descent from a species, but in itself including the characteristics of all the species belonging to that natural family ; or, in other terms, proving hereditary descent to have a relation primarily to genus or natural family. By this term I endeavour to explain family likenesses commingling with the generic ; the greater or less resemblance, for example, of an individual with other affiliated races, to none of which it belongs by strict hereditary descent. My ultimate aim is to offer a scientific explanation of the appearance, from time to time, of seemingly new species on the earth, and of the extinction of others, thus restoring to legitimate science that branch of philosophy which the theory of successive creations, invented by Cuvier and still maintained by his followers, had clearly removed from it. To prove the unity of the organization, the unity of creation, and the serial unity of all that lives or has ever lived, forms the aim of the first part of this inquiry.

"Probably no class of animals presents so many subjects for deep contemplation to the philosophic naturalist as the class fishes. They have furnished the chief materials for the transcendental anatomy of the skeleton ; in the history of the branchial arches we have the refutation of the 'arrest of development' theory ; in the external characters of the young salmon we have the proofs that in the young of any of the family of the salmonidæ we may find the types of all the adult species of the family, thus rendering doubtful the theory of the transmutation of species, and offering the only probable solution of the most difficult of all questions—the appearance of new species and even genera on the surface of the globe. Lastly, it is in the same class, fishes, that we find most distinctly, specialisations recalling the antique forms of animals which have long ceased to be. In the metamorphosis of the young salmon, the fins have at first forms which belong to extinct species ; next a dentition, so perfect, so complete, as to embrace the adult formulæ of all existing species of the family, so that to convert the dentition of one species into another, nothing is ever added, but merely a something left out. Contrary, then, to the theories of those who maintain that the adult alone is *perfect,* we find that it is the young which, typifying the *genus*, is entitled to that character. Lastly, it is in them that a portion of the nervous system acquires a development equal to the production of electricity ; and in certain of the class it is that we find the remains of a skeleton, the tegumentary, which in the extinct world prevailed to an extent of which we now can scarcely form an idea.

"In the *ganoid* or mailed extinct fishes, the skeleton which, from its connexion with the skin, may be called tegumentary or dermoid (but to which probably the more appropriate name of neuro-skeleton, as protecting the extremities of the nervous papillæ, might be better applied), reached its highest development as regards the class fishes ; in the present or living zoology, only two genera of fishes exhibit a similar arrangement of the tegumentary skeleton, namely, the lepidosteus of the Ohio, and the polypterus of the Nile. In the sturgeon we find a very complete tegumentary skeleton, but not arranged in the admirable mechanical manner of the extinct *ganoid* fishes."—R. K.]

SECOND PRIMARY DIVISION.

THE ANNELIDES OR ENTOMOZOARIA.

§ 507. The animals composing this division are so distinct from the preceding as to be recognised at a glance. Their bodies, in fact, are composed of segment-like rings, placed in a file behind each other. In some, this *annulated* appearance is confined to the existence of a certain number of transverse folds grooving the skin and engirdling the body, but in most the animal is enclosed in a sort of solid armour, composed of a series of rings united to each other, or so articulated as to admit of motion. This armour serves the purpose in some measure of a skeleton, for it determines the general form of the body, protects the soft parts, offers points of attachment for the muscles, and performs the office of levers ; thus, it is often called an *external skeleton.* But it must not be forgotten that it is merely the skin hardened and become rigid, or even encrusted with a calcareous epidermis, and thus is, at most, a *tegumentary skeleton.*

§ 508. In certain of the articulata or annelides, as in the scolopendra (Fig. 164), the rings strictly resemble each other; and this tendency to repetition is worthy of observation. Each ring may carry two pairs of appendages or limbs, one belonging to its dorsal arch or upper portion (Fig. 413), the other to the lower or ventral; and when these appendages happen to be but little developed, all the rings are, in fact, provided with limbs. But in general the appendages of certain rings acquire a large development, as if at the expense of the others, which in this case remain rudimentary. It almost always happens that it is the lower appendages which are thus developed, and which assume varied forms, according as the animal is higher or lower in the scale. Differently modified, they form the antennæ, the various organs of mastication, the feet, fins, &c. (Figs. 143, 144). Sometimes the upper appendages remain and perform, like those of the inferior arch, the office of feet: various annelides offer examples of this; but generally they exist merely on the rings situated towards the middle of the body, and they constitute the wings, or organs held as analogous to them. The feet are generally three, four, five, or seven pairs in number, but occasionally they are in hundreds, and sometimes altogether absent; in that case, they seem to be represented by coarse hair in bundles, as may be seen in earth-worms.

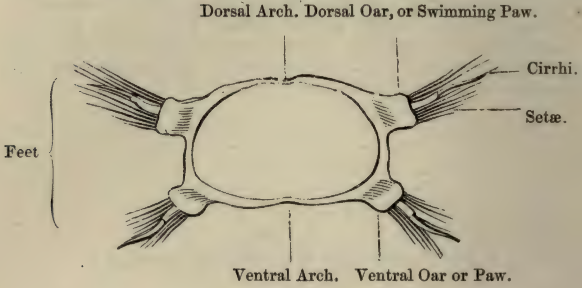

Fig. 413.—Vertical Section of a Ring or Segment of the Body of an Annelide of the genus Amphinome.

§ 509. The tendency to repetition, so remarkable in the tegumentary skeleton of the annelides, extends to the muscles, nervous system, and others. In general each segment has a pair of nervous ganglions; all these are united to each other by a double chain of communicating filaments occupying the median line of the body near its ventral aspect (Fig. 162). In most of the inferior articulated animals, and in the more elevated, but whose development is not finished, these ganglions are almost all equal, and form, thus connected together, two chains resembling knotted cords from one end of the body to the other (Fig. 414); but, as we ascend in the scale, we find a disposition in these ganglions to a fusion, in the lateral and longitudinal sense (Fig. 415), so as to form a mass. In crabs, this centralization is carried so far as to form but two nervous masses for all the rings or segments of the body,—one situated in the head, the other in the thorax; but even in this case the nervous collar encircling the gullet is always found, so that two such masses seem the maximum of nervous fusion. In the mollusca we also find the nervous collar; but the ventral or post-œsophagal gan-

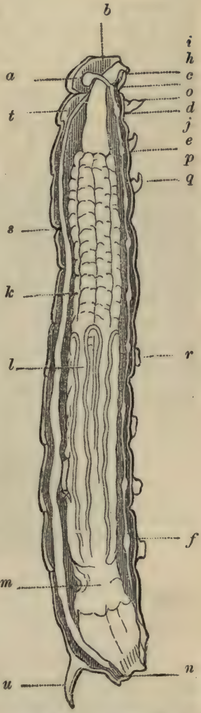

Fig. 414.—Anatomy of the Sphinx.*

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* Privet Hawk-moth: *a*, cephalic ganglions, or brain, situated before the gullet, and giving origin to the optic nerves, &c.; *b*, nervous cords of communication, connecting the first pair of ganglions with the second, and in their course encircling the gullet; *c*, first pair of post-œsophagal ganglions situated behind the mouth; *d*, ganglions of the first ring, or segment of the thorax; *e*, nervous mass formed by the ganglions of the second and third thoracic rings; *f*, sixth pair of abdominal ganglions; *h*, the mouth; *i*, the proboscis; *j*, the gullet; *k*, the stomach; *l*, the intestine and biliary vessels; *m*, large intestine; *n*, the anus; *o*, feet of the first pair; *p*, feet of the second pair; *q*, feet of the third pair; *r*, first pair of membranous feet of the larva; *s*, dorsal vessel; *t*, first ring of the thorax; *u*, horn surmounting the extremity of the abdomen in the larva.

glionary portion is composed in them of only one or two pairs of ganglions situated on the median line of the body; whilst in the annelides we find a long series of ventral ganglions; and when we find in this part of the body merely a single nervous mass, we know well that it is the result of a fusion of several ganglions.

Anatomists find in the cephalic ganglions the analogues of the brain, and in the knotted cord of insects the spinal marrow of the vertebrata; but such views are questionable, and if any analogy existed, it would rather be found in the ganglions situated on the posterior roots of the spinal nerves.

§ 510. In respect of the nervous and locomotive systems, the annelides stand higher than the mollusca; but, as regards the functions of vegetative life, their circulatory system is less complete, and is occasionally altogether absent. In general their blood is white, but not in all, and this difference seems not much to affect them. Their mode of respiration varies; their digestive tube extends from one extremity of the body to the other; the mouth is placed in the head, and the anus at the other extremity. Finally, there exist almost always jaws, or at least particular instruments for the prehension of the food, and these organs are always disposed laterally, in pairs, instead of vertically, and before each other, as in the vertebrata.

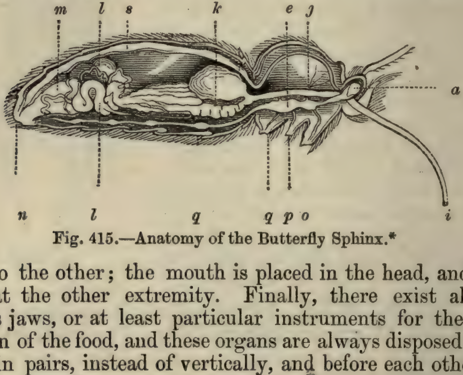

Fig. 415.—Anatomy of the Butterfly Sphinx.*

This primary division is subdivided into two groups: first, articulated animals, properly so called; second, vermes or worms. In these there are no limbs, or at least they are represented merely by tubercles furnished with hairs (setigerous), and the organs of generation are so degraded as to become at last extremely imperfect.

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* The different parts are indicated by the same letters as in the preceding figure.

SUB-DIVISION.

ANTHROPODARIA OR ARTICULATED ANIMALS,

PROPERLY SO CALLED.

§ 511. Articulated animals owe their superiority to the class vermes to the superior development of their nervous and locomotive systems, and to the more complete localization of their organs. Some of these characteristic differences have been already pointed out (§ 380). The following synoptic table may therefore suffice to recal certain of the characters peculiar to the various groups.

ARTICULATED ANIMALS, *properly so called.*

Aerial respiration by tracheæ, or pulmonary sacs.	A head distinct from the thorax, furnished with antennæ.	Body composed of three distinct portions, head, thorax, and abdomen; three pairs of feet; generally wings.	Insecta.
		No distinction between the thorax and abdomen; twenty-four pairs of feet or more; no wings.	Myriapoda.
	Head not distinct from the thorax; no antennæ.		Arachnida.
Aquatic respiration by branchiæ.	In general five or seven pairs of feet.		Crustacea.

CLASS INSECTS.

§ 512. To the definition given of this class of animals in the annexed synoptic table, we have only to add, that they have no vascular system properly so called, and that nearly always they undergo metamorphoses when young. They are the only invertebrate animals organized for flight.

§ 513. The tegumentary skeleton of insects, that is, the hardened integuments, preserves sometimes a certain flexibility, but has generally a consistence resembling horn. It is not horny, however. A substance called *chiline* forms the base. It is composed of several pieces, so united as to admit of motion.

The body, as already described, is composed of rings or segments placed in a pile; and in this series of segments three portions are distinguished,—the *head*, *thorax*, and *abdomen*.

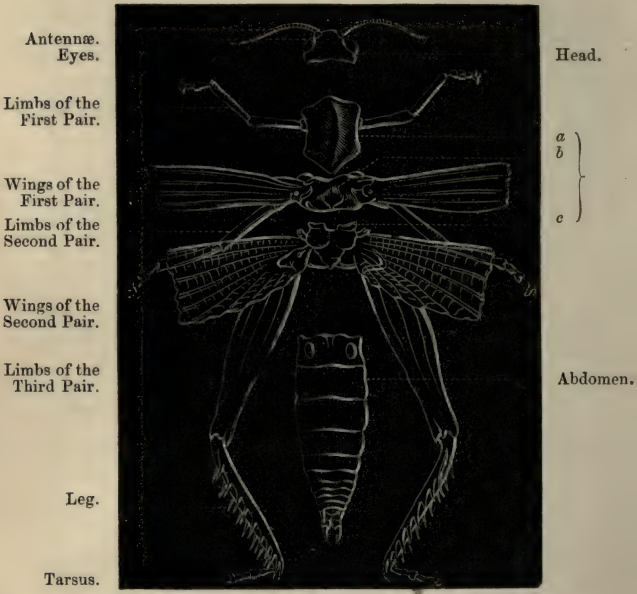
Antennæ.
Eyes.
Head.
Limbs of the First Pair.
a
b
Wings of the First Pair.
Limbs of the Second Pair.
c
Wings of the Second Pair.
Limbs of the Third Pair.
Abdomen.
Leg.
Tarsus.

Fig. 416.—Anatomy of the Tegumentary Skeleton of a Grasshopper.

The members or appendages connected with these different rings have a structure analogous to the trunk of the animal; they are composed in fact of solid tubes or horny plates, enclosing in their interior muscles and nerves intended to move them.

The head is formed of a single segment, and carries the eyes, antennæ, and appendages of the mouth. The antennæ constitute the first pair of the members or appendages of insects, and are composed of a number of joints placed one before the other. They arise from the anterior or superior part of the head, and affect in general the form of flexible slender horns (*a*, Fig. 417); but their conformation varies, especially in the males. In some they resemble feathers (Fig. 419); sometimes saws and little clubs (Fig. 418); and occasionally they are formed of little lamellæ, like the leaves of a book (Fig. 421). Their length is sometimes very considerable. Of their use nothing is known for certain; but they may serve for feeling or even hearing.

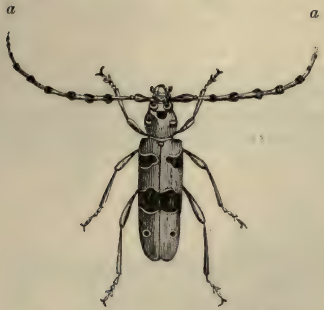

Fig. 417.—Capricorn of the Alps.

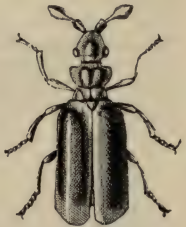

Fig. 418.—Horny Paussus.

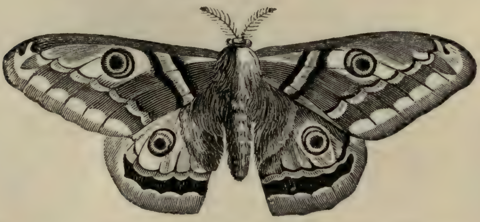

Fig. 419.—Small Bombyx (*Paon de Nuit*); Emperor Moth.

Three pairs of other appendages arise from the lower part of the head, constituting organs of mastication or suction. We shall return to these when speaking of digestion (§ 421 and 522).

§ 514. The thorax of insects occupies the middle portion of the body, and carries limbs and wings. It is always composed of three circles or rings, named *prothorax*, *mesothorax*, and *metathorax* (*a b c*, Fig. 416); and it is to the ventral arch of each of these rings that one of the pairs of limbs are fixed. The wings, on the contrary, spring from the dorsal arch of the thoracic rings; but the *prothorax* (*a*) never carries any, and there never exists more than a pair of these appendages on each of the two following rings, so that there are never more than two pairs.

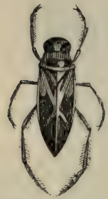

Fig. 420.—Notonectes. Boat Fly.

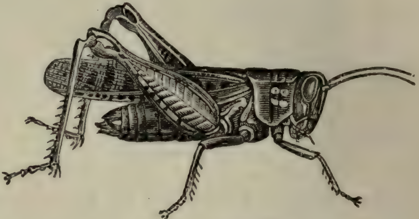

Fig. 421.—Cricket.

§ 515. In the limbs of insects we distinguish a haunch composed of two joints, a thigh, and leg, and a sort of foot called *tarsus*, divided into several joints, the number of which varies from two to five. They terminate in nails. It may be readily imagined that their forms vary in unison with the habits of the animals. Thus, insects which have the hinder limbs long (Fig. 421), leap rather than walk. In insects which swim, such as the dysticæ, the notonectes (Fig. 420), and the gyrini, commonly called whirlygigs (Fig. 422), the tarsi are generally flattened, ciliated, and disposed like oars; and in those which can walk on smooth surfaces with the body suspended, we find on the terminal joint a sucker, by which they adhere to the body they touch. Sometimes, also, the anterior limbs are enlarged, as in moles, to enable them to dig into the soil. The mole-cricket (Fig. 423), which does

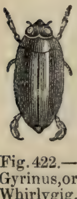

Fig. 422.—Gyrinus, or Whirlygig.

such mischief by cutting the roots in its course, is an example of this arrangement.

There are also species in which these same limbs form organs of prehension, the leg being flexible and disposed like a claw, the edge being armed with spines. The mantis religiosa (Fig. 424), a large insect of the south of France, is armed in this way.

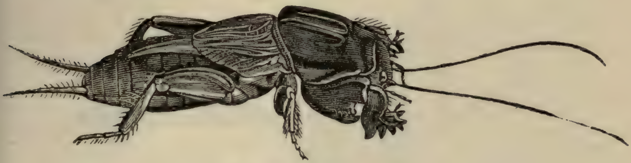

Fig. 423.—Mole-cricket.

Finally, there are insects (several diurnal butterflies, Fig. 425) in which the anterior limbs are so small or rudimentary as to escape notice, as if they had only four pair of limbs.

§ 516. The wings of insects are laminated appendages, composed of a double membrane, supported internally by more solid "nervures." When scarcely developed, they are soft and flexible; but they soon dry, and become stiff and

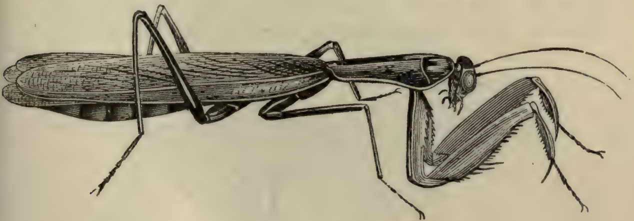

Fig. 424.—Mantis Religiosa; Religious or Praying Mantis.

elastic. There are never more than two pairs, sometimes only one, and they vary in form; they always spring from the last two rings of the thorax. When they really serve for flight they are thin, translucent, and covered with microscopic scales like dust, as is seen in butterflies; but the anterior wings often become hard and opaque, and becoming useless, as wings form *elytra, i. e.,* protecting sheaths for the others (*a*, Fig. 426). At other times these same wings, still membranous towards their extremities, become hard and opaque at their base, and are then called *semi-elytra.*

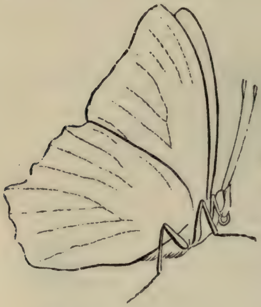

Fig. 425.—Morphe.

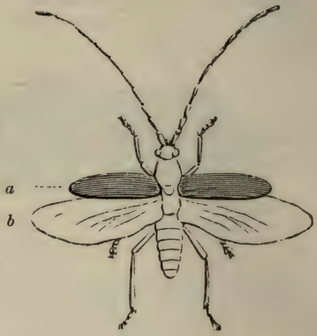

Fig. 426.—Capricorne Charpentier.

There are insects in which the wings, instead of being laminated, are cleft into a number of membranes, barbed on the edges like feathers, disposed like a fan. This may be seen in the genus pterophore and orneode (Fig. 427). Finally, when the posterior wings are wanting, they are

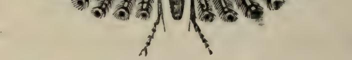

Fig. 427.—Ornéode; Plumed Moth.

usually replaced by two small moveable filaments, terminated like a club, and named balances (Fig. 428).

§ 517. The abdomen of insects is composed of a considerable number of rings, moveable on each other. As many as nine may be counted, and when there are fewer it seems as if some had become fused. In the perfect insect, these rings or segments have neither wings nor limbs; but those occupying the posterior extremity of the body give origin to appendages varying both in form and size. Sometimes they are simple hairs or stylets, whose functions are not well known, as in the ephemera, for example (Fig. 458). Sometimes these organs affect the forms of hooks, and constitute more or less powerful forceps, as in the forficula or earwig (Fig. 429).

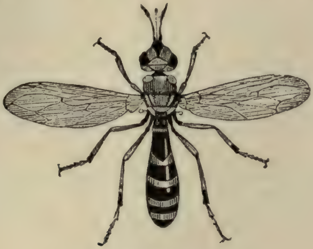
Fig. 428.—Conops.

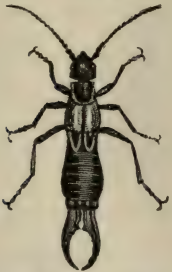
Fig. 429.—Forficula;
Earwig.

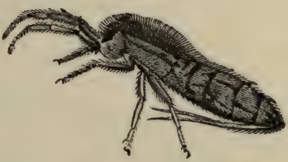
Fig. 430.—Podurella;
Skiptail.

Sometimes they answer the purpose of a spring, to enable the animal to move forward, as in the podurella (Fig. 430), small insects, which in our climate conceal themselves under the stones, or float to the surface of stagnant waters, and which are sometimes found under the snow in the coldest regions of the globe. Finally, these abdominal appendages have at other times a more complex structure, and form an offensive weapon, as in bees and wasps, or an apparatus destined to secure a depôt for the eggs of the insect in a place adapted for the development of the young. The sting of the wasp and bee is formed of two sharp stylets, lodged in a horny stalk or sheath, having each a furrow, along which flows the poison secreted in a small gland situated close to it. In the state of repose, the whole apparatus is drawn within the body of the animal; but when the insect wishes to use it, the sheath is protruded, and along with the sting is driven into the skin of its enemy. Sometimes it is imposible to withdraw it, and the whole sting separates then from the body, remaining implanted in the wound, causing the speedy death of the insect. The male is always stingless, and thus can be handled without danger; but the female and the working bee are provided with it, and its sting produces a very painful inflammation. The auger of the fœnus (Fig. 431), of the ichneumons, and of many other insects, has a somewhat analogous arrangement; and we remark also, in general, a serrated edge, by which the ichneumon divides the entrails of the animal or the tissue of the vegetable in which it purposes depositing its eggs. It is by piercing in this manner an oak of the Levant that a small insect called cynips gives rise to the formation of the gall-nut, of which so much use

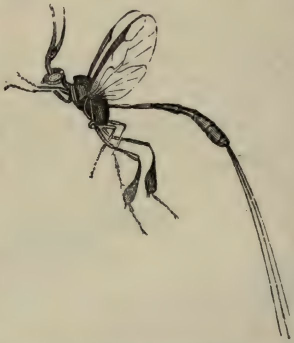

Fig. 431.—The Fœnus; Ichneumon or Cuckoo Fly.

is made in the fabrication of ink and in the preparation of dark dyes. The small fissure produced by the auger of the insect gives rise to an effusion of vegetable juices, and this produces an excrescence, in the centre of which may be found the eggs of the cynips.

§ 518. Insects have the organs of sense highly developed; they possess sight, smell, as well as tact, taste, and hearing; but hitherto the organs of olfaction and audition have not been discovered: but little is known of the organ of taste. The structure of the eyes differs very much from that of the higher order of animals. In general, the organ which at first sight appears to be a single eye, is in reality formed by the agglomeration of a number of small eyes, having each a cornea, vitreous humour of a conical form, a layer of colouring matter, and a nervous filament. In the may-bug, for example, we find nine thousand such in a single compound eye, and there are insects which have more than twenty-five thousand. All these small corneæ are hexagonal, and unite together so as to form a kind of common cornea, whose surface presents a vast number of facettes. Moreover, each of these small constituent parts of these multiple or compound organs is quite distinct from those around it, and forms with them a bundle of tubes, each terminating in a nervous filament, proceeding from the terminal enlargement of the same optic nerve. Almost all insects have a pair of these compound eyes; but they are sometimes replaced by simple eyes, and at other times both sorts are present. The simple eyes, also called *stemmata*, have the greatest analogy with the structure of each of the elements of the compound eyes. In general, these simple eyes form a group of three on the summit of the head. Nothing precise is known respecting the manner in which these eyes act on the light, nor of the mechanism of vision in insects.

§ 519. Several insects have the power of producing sounds, which they do by friction of certain parts of their body on each other, or they may depend on the movements impressed on the special instruments for the contraction of the muscles. The monotonous and deafening sounds of the balm cricket, or chirping grasshopper, result from alternate tension and relaxation of an elastic membrane, disposed like the skin of a drum, over the base of the abdomen; in crickets, the sounds are caused by certain parts of the wings, which, rubbing against each other, vibrate intensely, and the structure producing this is very singular; but the buzzing of flies appears to depend on the rapid escape of the air through the thoracic stigmata during the violent movements of flight. Finally, there are other insects which produce sounds by a mode as yet unknown, such as the nocturnal butterfly or death's-head sphinx.

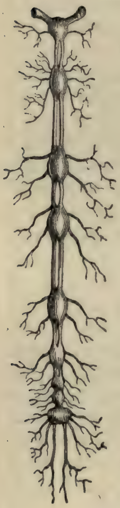

Fig. 432.

§ 520. The nervous system of insects has been already in a great measure described (§ 509). It is composed principally of a double series of ganglions, reunited by longitudinal cords (Fig. 432); the number of the ganglions corresponds to the number of rings; sometimes equidistant and extending from one end of the body to the other, at other times they approach each other, and become confused into a nervous mass. The cephalic ganglions are large, and give origin to the nerves of the eyes and antennæ, &c. The first pair of ganglions behind the gullet give off the nerves of the mouth, and the longitudinal filaments connecting them with the cephalic ganglions from the nervous collar surrounding the gullet. Finally, the brain gives off on each side a nerve, which, ascending on the stomach and uniting with that of the opposite side, constitutes a median nerve, situated above the digestive canal, and having in its course two ganglions. The three pairs of ganglions following behind the gullet belong to the three rings of the thorax, and give off the nerve of the limbs and wings; generally speaking, they are very near each other, and much larger than the following pairs, which belong to the abdomen.

§ 521. Insects vary much in their mode of nourishment, some living on the juice of plants, whilst others feed on solid aliments, and are either carnivorous or phytophagous; and these differences correspond to a remarkable modification in the structure of the mouth. In the grinding insects, such as the scarabei, the may-bug, the blatta (Fig. 433), the grasshoppers, the opening of the mouth is furnished anteriorly with a median piece called labium, or upper lip (*a*, Fig. 434), and presents on each side a kind of large moveable tooth, very hard, and called mandible (*b*, Fig. 434), which serves to divide the food. Immediately behind these are the

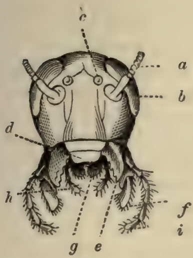

Fig. 433.—Head of the Blatta, (Cockroach) viewed before.[*]

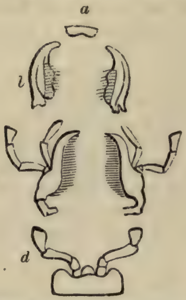

Fig. 434.—Buccal Appendages of the Carabus; Beetle.

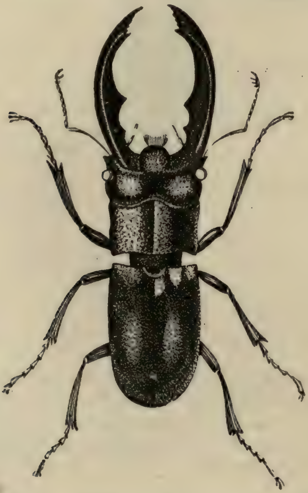

Fig. 435.—Lucanus Metallicus; Heron Beetle.

[*] *a*, antennæ; *b*, compound eyes; *c*, single eyes; *d*, labium; *e*, mandibles; *f*, jaws; *g*, little tongue; *h*, labial palpi.

more complex jaws (*c*, Fig. 434). Each of these last organs offers besides a plate or a cylinder, more or less hard, armed with small teeth or hairs, and carries on its outer side one or two small stalks composed of several joints, called maxillary palpi. Finally, behind the jaws is a second pair of appendages, whose base is supported by a median horny piece, called the chin (*d*); these appendages constitute the languette or little tongue. They are applied against the jaws as those are themselves applied against the mandibles; there exists besides a pair of articulated and moveable filaments called labial palpi, because the name of lower lip is usually given to the chin reunited to the languette. These different parts vary according to the nature and consistence of the food. The palpi serve principally to seize the food and to hold it between the mandibles whilst they divide it. Sometimes the jaws assume an enormous development, forming a sort of forceps in front of the head; this arrangement is very remarkable in the heron beetle (Fig. 435), and in the other species of the genus lucanus.

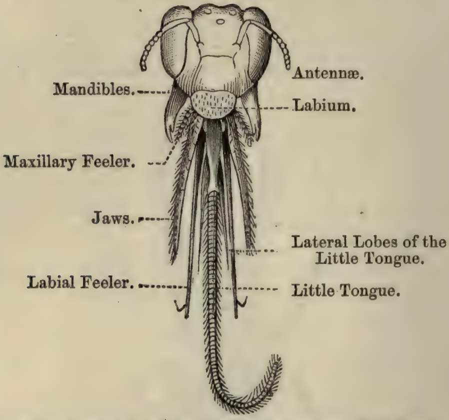

Fig. 436.—Head of the Anthophora Retusa, or Wild Bee.

§ 522. For sucking instruments the jaws and the labium become elongated, so as to form a kind of tubular proboscis, in the interior of which there are often delicate filaments, performing the functions of little lancets, and formed of the mandible and jaws, extremely modified.

In bees, in the anthophora, wild bee, the bourdon or solitary bee, and other insects, called by zoologists hymenoptera, the buccal apparatus presents a disposition in some measure intermediate between these two extremes. The upper lip (*a*, Fig. 437) and the mandibles (*b*) greatly resemble those of the grinding insects; but the jaws (*c*) and the languette (*d*) are extremely elongated, and the first assume a tubular form longitudinally, encasing the sides of the languette, so that these organs, reunited into bundles, form a proboscis, serving to conduct the food, always soft and liquid, on which these insects live. This proboscis is moveable at its base, and flexible throughout the rest of its extent, but it is never rolled up, as we see in the butterfly. With regard to the

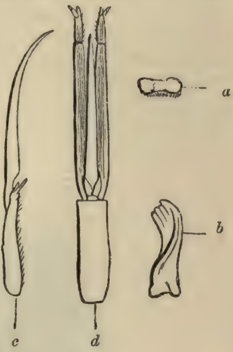

Fig. 437.

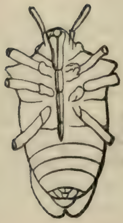

Fig. 438.—The Wood-Bug.

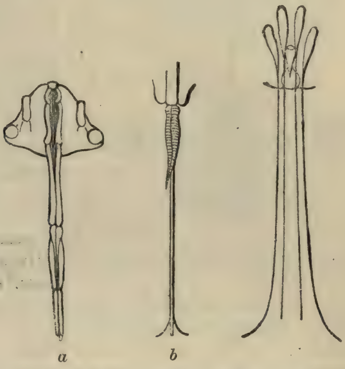

Fig. 439.—Buccal Apparatus of a Hemipterous Insect.

mandibles, they serve chiefly to cut the materials with which the hymenoptera make their nest, or to seize and put to death the prey of which these insects suck the juices. It has been remarked also, that there exist in the interior of the mouth other solid pieces which are absent in the grinding insects, and which constitute valvules intended to close the pharynx every time that deglutition does not take place.

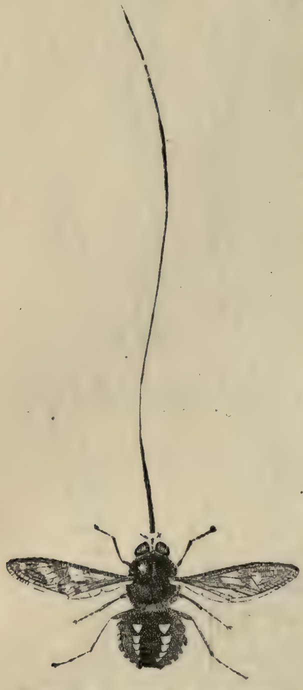

Fig. 440.—Nemestrina longirostris.

§ 523. In the wood-bug, the chirping grasshopper, the vine-fretter, and other hemipterous insects, the apparatus of suction is composed of the same elements, but a little differently arranged. The mouth is armed with a tubular and cylindrical bill or beak, directed downwards and backwards (Fig. 438), and composed of a sheath enclosing four stylets; the sheath (*a*, Fig. 439) is in its turn formed of four joints, placed end to end, and represents the lower lip; finally, the stylets (*b c*), which have the form of slender filaments, stiff and serrated at their summit, to enable them to pierce the skin of animals or the tissues of plants, are the representatives of the mandibles and jaws, extremely elongated. In the hemiptera, which live at the expense of animals, the bill is in general very strong, and folded into a semicircle under the head. In those which are nourished on the juices of vegetables, it is, on the contrary, almost always slender, and applied in repose against the inferior surface of the thorax between the limbs. Its length is sometimes so considerable that it passes backwards beyond the posterior extremity of the abdomen.

In the flies the proboscis, sometimes soft and retractile, sometimes horny and elongated, represents also the lower lip, and often carries feelers on its basis; a longitudinal groove occupies the superior surface and lodges the stylets, whose number varies from two to six, and whose analogues in the bruising or grinding insects are the mandibles, the jaws, and the languette or little tongue. Sometimes this proboscis acquires an enormous length (Fig. 440), sometimes, on the contrary, it is scarcely visible.

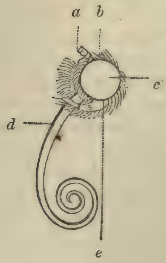

Fig. 441.—Proboscis of a Butterfly.*

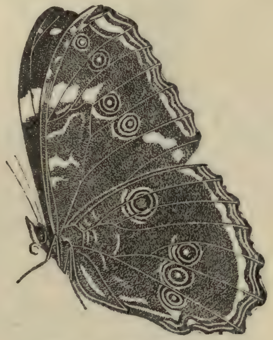

Fig. 442.—Morpha Hélénor (Vampa).

§ 524. Finally, in the butterflies (Fig. 424), which are also nourished on liquid substances, but which are found at the bottom of flowers, and which have no occasion for cutting or piercing instruments to obtain them, there no longer exist stylets performing the functions of lancets, as in the preceding, and the mouth is furnished with a long proboscis (*c d*, Fig. 441), rolled into a spiral, and composed of two filaments, hollowed into a groove on their inner surface, which are nothing but jaws extremely elongated and modified in their shape. At the base of this proboscis we distinguish anteriorly a small membranous piece, which is the representative of the labium or lip, and on each side a small tubercle, the last vestige of the mandibles. We observe also here the rudiments of the maxillary palpi, and behind is found a small triangular lip carrying two very large labial palpi, composed of three joints, and almost always velvety and covered with scales (*e*).

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* *a*, head; *b*, base of the antennæ or feelers; *c*, the eye; *d*, the proboscis; *e*, palpi.

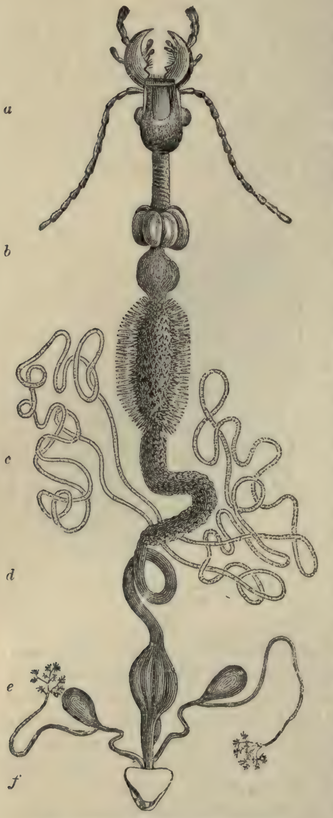

Fig. 443.—Digestive Apparatus.*

§ 525. The alimentary canal presents in general a sufficiently complex structure; sometimes it is straight, and offers pretty nearly the same diameter throughout its whole length; but in general it is more or less flexuous, and has several successive enlargements and contractions. We distinguish, then (Fig. 443), a pharynx, a gullet, a first stomach or crop, a second stomach or gizzard, whose walls are muscular, and often provided with horny parts adapted to triturate the food; a third stomach, called the *chylifying stomach*, whose texture is soft and delicate; a small intestine, a cæcum, and a rectum. As in the superior animals, we observe a relation between the nature of the food and the development the canal requires; in carnivorous insects it is in general very short, whilst in insects which are nourished on vegetable substances it is in general very long. The food which reaches it is imbibed with saliva; the apparatus which secretes this liquid consists in a certain number of floating tubes, terminating sometimes by kinds of utricles, and communicating with the pharynx by excretory canals. A multitude of villosities with which the *chyle-forming stomach* is usually furnished, seem to serve for the secretion of a gastric juice, and it is also in this cavity that the bile is poured. There exists no liver, properly speaking, in insects; but this organ is replaced by long and delicate tubes, which float in the interior of the abdomen, and open superiorly into the chyle-forming stomach (*c*, Fig. 443). These biliary vessels also take the place of urinary glands, for it is here that the uric acid is formed. By one of their extremities they always open into the chyle-forming stomach, and the other extremity is sometimes free, sometimes fixed to the intestine, whether near the first opening or in the neighbourhood of the rectum. Finally, we still find, towards the posterior extremity of the intestinal canal, other secreting organs (*e*) serving to elaborate particular fluids (such as the venom of the bee) which several insects eject from the extremity of the abdomen when they are disturbed.

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* *a*, head carrying the antennæ, mandibles, &c.; *b*, crop and gizzard, followed by the chyle-forming stomach; *c*, biliary vessels; *d*, intestine; *e*, secreting organs; *f*, anus.

§ 526. It would appear that it is by simple imbibition that the chyle traverses the walls of the digestive tube, and mingles with the blood. This last liquid is watery and colourless; it is not enclosed in vessels, and is found spread about in the interstices which the organs have between them, or present in the substance of their tissue. Insects also have no regular circulation. We perceive, indeed, in certain parts of their bodies, currents even sufficiently rapid, but the nourishing liquid does not describe a circle so as to return constantly to its point of departure. There exists, in fact, in these animals only the vestiges of the circulating apparatus (§ 112). We observe near the dorsal surface of the body a longitudinal tube (Figs. 414 and 415), which performs alternate movements of contraction and of dilatation, analogous to those of the heart in the superior animals. But this dorsal vessel seems to give off no branch. The nourishing liquid penetrates into it by lateral openings, furnished with valvules to prevent its repulse, and escapes from it by its cephalic extremity. Moreover, the motion of the blood does not depend altogether on this organ, for there have been discovered in several insects moveable valvules, whose pulsations determine in this liquid rapid currents, and strange to say, it is in the limbs that this apparatus is lodged.

§ 527. The blood become venous by its action on the different tissues of the economy, is thus unable to reach a determinate part of the body, to place itself in contact with the oxygen, and thus to recover its vivifying qualities. If the respiration were accomplished in the ordinary way, by the aid of lungs or by the external surface of the body, it would have been consequently extremely incomplete; but the disadvantage which would seem necessarily to have resulted from this great imperfection in the so important function of the circulation does not in reality exist. Nature has made amends for the rapid and regular transport of the blood by conducting the air itself into all parts of the body by means of a multitude of canals which communicate with the exterior, and are infinitely ramified in the substance of these organs (Fig. 57).

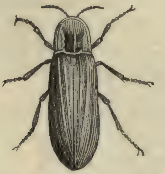

Fig. 444.—Male Lampyris (Glow-worm)

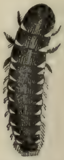

Fig. 445.—Female Lampyris.

These air-bearing tubes, designated, as we have already said (§ 133), under the name of *tracheæ*, present a complex structure; they are composed generally of three tunics, of which the middle one is formed of a cartilaginous filament rolled into a spiral, like the elastic of a strap (*bretelle*). Sometimes they are simple, but at other times they present a certain number of large swellings, in the form of soft vesicles, which perform the functions of a reservoir of air (Fig. 57). The apertures by which the air penetrates into the trachea are called *stigmata;* they resemble in general a small button-hole, but these often have valves which open and shut like the folding or clapper of a door. A pair may generally be seen on the lateral and upper parts of each ring; but they are often absent in the last two segments of the thorax.

With regard to the mechanism by which the air is renewed in the interior of this respiratory apparatus, it would seem to consist generally in the movements of contraction and dilatation of the abdomen. Thus, as we have already said elsewhere, the respiration is very active in these animals. They consume a considerable quantity of air, compared with their bulk, and speedily asphyxiate when deprived of oxygen; but when they are in this condition of apparent death, they can continue so for a great length of time without losing the faculty of returning to life.

§ 528. Most insects produce but very little heat; but some of these animals disengage, under certain circumstances, a sufficiency notably to raise their temperature. Bees offer an example of this, especially when they are much agitated in their hive; and it is to be observed that the respiration becomes then very active.

§ 529. Another and a more remarkable phenomenon, and of which the cause is still unknown, is the production of light observed in some insects. The lampyris or *glow-worm* is an example of this, well known to all who frequent the fields: the male (Fig. 444), which has wings, is but little luminous; the female (Fig. 445), which has no wings, and which is often found during the warm nights of summer on the thickets, spreads around a very lively phosphorescent light. In another species of lampyris inhabiting Italy, the individuals of both sexes are at the same time winged and luminous; but this singular property is especially remarkable in certain taupins inhabiting the hot regions of America, and which produce, whilst they vault in the obscurity, a natural illumination of the happiest effect; the women frequently place them in their hair as ornaments, and it is asserted that the Indians make use of them to point out the way during the night. In one lampyris, the light comes from certain spots situated over the two or three last rings of the abdomen; whilst in the taupins it comes from analogous spots over the prothorax or corslet. It appears that the insect can vary at will the intensity of the phosphoric light, and that it is connected with the action of the oxygen upon a fatty matter secreted by the phosphorescent organs.

§ 530. The sexes are distinct in these animals, and there exist often great differences between the male and the female: the common lampyris has already offered us an example (Figs. 444, 445). Almost all insects lay eggs: nevertheless, some are viviparous. There often exists at the extremity of the abdomen of the female a dart, a wimble, or some other organ, destined to form holes adapted to receive the eggs; and by an admirable instinct the mother uniformly deposits these in a place where the young will find themselves in proximity with the food they require, even although it be in most cases not the kind which the parent lives on.

In youth, insects change their skin several times, and present almost always a phenomenon of the most remarkable kind, of which, however, we have already seen an example in the batrachia. Most of them, on quitting the egg, neither resemble their parents nor what they will themselves afterwards become, and undergo, before arriving at the perfect state, changes so considerable as to constitute a true *metamorphosis.*

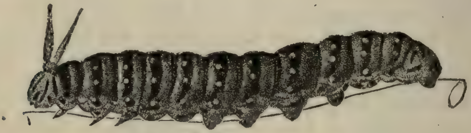

Fig. 446.—Swallow-tailed Butterfly (Larva of the Butterfly Machaon).

In general, insects pass through three conditions, quite distinct, which have been named the *larva state* or condition (Fig. 446), the *nymph state* (Fig. 447), and the *perfect state* (Fig. 448); but the changes they undergo are not always equally great. Sometimes these changes render the animal altogether unrecognisable, at other times they consist only in the development of wings; and these various degrees of transformation are known by the names of *complete metamorphoses* or of *semi-metamorphoses.*

§ 531. Insects which undergo a complete metamorphosis are always more or less vermiform when they leave the egg and when they are in a state of larva (Fig. 446). Their body is elongated, almost entirely soft, and divided into moveable rings, of which the regular number is thirteen. Sometimes they are altogether without limbs: at other times they have a variable number of these organs, but whose conformation in no shape resembles that of the same parts in the adult animal. Almost always they have merely simple eyes, and they are sometimes completely without any. Finally, their mouth is almost always armed with mandibles and jaws, whatever be the conformation which they assume in the end; and we often see the first of these organs serve for locomotion as well as for the prehension of the food. These larvæ vary, moreover, in their form, and are known sometimes under the name of *cheville* (caterpillars); sometimes, but erroneously, under the name of *worms*.

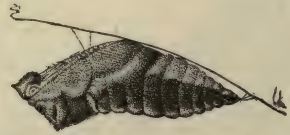

Fig. 447.—Chrysalis of the Machaon; Swallow-tailed Butterfly.

After having remained in this condition during a longer or shorter period, and after having experienced several *moultings*, their wings form under the skin, and they change into nymphs (*chrysalids*). During the whole duration of this second period of their existence, these singular animals cease to take food, and remain immovable. Sometimes the skin which they have just shed dries up, and forms a sort of oviform case, in the interior of which they remain enclosed; sometimes they are only covered with a thin pellicle, which, applied closely over their external organs, follows all their contours, and resembles linen, in which the insect is encased or bandaged. This last arrangement, which is seen in the nymphs of butterflies or *chrysalids* (Fig. 447), has obtained for them the name of *pupa* or of *maillot*.*

Before undergoing this metamorphosis, the larva often prepares a refuge, and shuts itself up in a case, which it makes with silk, secreted by glands analogous to the salivary glands, and prepared by means of winders hollowed out in its lips. At other times it suspends itself by means of filaments (Fig. 447), or conceals itself in some hole. It is while the insect is in this state of apparent repose that there takes place in the interior of its body an active labour, the result of which is the complete development of all its organization. Its internal parts soften, and by little and little assume the form which they are afterwards to maintain. The various organs with which the adult animal is to be provided become developed under the envelope concealing them, and when this evolution is finished, it frees itself of this kind of mask, unfolds its wings, which soon acquire consistence, and becomes a perfect insect.

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* Literally, swaddling-clothes.

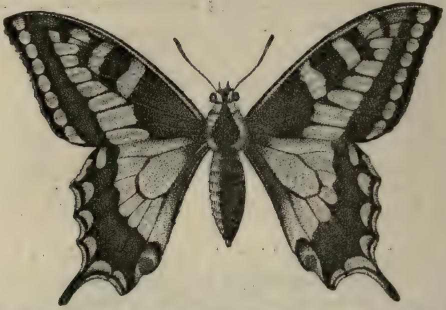

Fig. 448.—Papillon Machaon; Swallow-tailed Butterfly.

§ 532. As an example of these metamorphoses, we could not choose a better than that of the *bombyx of the mulberry;* for this insect, in the state of a larva, is for us of immense interest. It is the silkworm, the rearing of which contributes so powerfully to the agricultural prosperity of our southern provinces, and whose products support so many wealth-producing employments. This insect, originally from the northern provinces of China, was introduced into Europe only in the sixth era. Some Greek missionaries brought the eggs to Constantinople during the reign of Justinian, and at the epoch of the first Crusades its culture spread into Sicily and Italy; but it was only in the time of Henry the Fourth that this branch of agricultural industry acquired some importance in our southern provinces, of which it forms, at the present day, one of the principal sources of wealth.

The eggs of the mulberry bombyx are known to agriculturists by the name of *seed of the silkworm.* When they have been exposed to the air they have an ashy-grey tint, and with some care they may be thus preserved for a sufficiently long time without becoming deteriorated. In order that incubation commence, and that the larvæ appear or unfold themselves, it is necessary that the eggs be placed for some time under the influence of a temperature of at least 15° or 16° Cent. (59° Fahr.). After having experienced eight or ten days of increasing heat they become whitish, and soon after the larvæ begin to come forth. These small animals at the moment of their birth are only about a line and a quarter in length. Their body (Fig. 449) is elongated, cylindrical, annulated, smooth, and generally of a greyish colour. At its anterior extremity may be distinguished a head, formed by two kinds of hard scaly caps, on which may be remarked black points, which are the eyes. The mouth occupies the anterior part of this head, and is armed with strong jaws. The three following rings have each a pair of small scaly limbs, and represent the thorax. Finally, the abdomen is very large, and has no limbs on the first two segments, but is furnished posteriorly with five pairs of fleshy tubercles, which resemble stumps, and which constitute so many limbs. In the south of France silkworms are called *magnans*, and hence the name of *magnanerie* given to the establishments in which they are reared. The first care they require after their birth is to separate them from their cocoons, and to

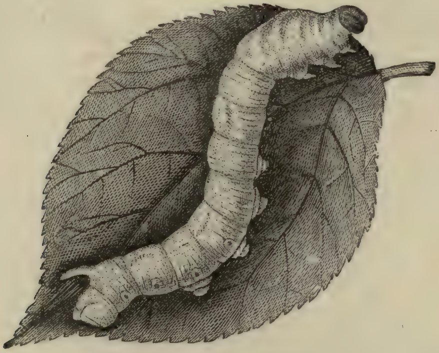

Fig. 449.—Silkworm.

place them on hurdles, where they find nourishment appropriate to their wants. For this purpose it is usual to cover the eggs with a sheet of perforated paper, through the holes made in which the worms ascend to reach the leaves of the mulberry placed above; and it is when they are on the branches furnished with these leaves that they are transported on the hurdles prepared to serve as their dwellings. The nourishment of the silkworm consists in the leaves of the mulberry (Fig. 449), and it is consequently on the culture of this plant that the possibility of rearing these insects depends. The white mulberry is the species most generally employed for this purpose; it is a tree which grows to the height of forty or fifty feet, and which gives four or five quintals* of leaves, sometimes even ten or twelve. It accommodates itself sufficiently well in most localities, and it has been cultivated with success even in the north of Europe, but it grows nowhere wild. In fact, this mulberry-tree is originally from China. Two Greek monks introduced it into Europe towards the middle of the sixth era, and the silkworm with it.† Its culture soon spread throughout the

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* Quintal,—one hundred pounds weight.

† "I need not explain that silk is originally spun from the bowels of a caterpillar, and that it composes the golden tomb from whence a worm emerges in the form of a butterfly. Till the reign of Justinian, the silkworms, who feed on the leaves of the white mulberry tree, were confined to China; those of the pine, the oak, and the ash were common in the forests both of Asia and Europe, but as their education is more difficult, and their produce more uncertain, they were generally neglected, except in the little island of Leos, near the coast of Africa. A thin gauze was procured from their webs; and this Leon manufacture, the invention of a woman, for female use, was long admired both in the East and at Rome. Whatever suspicions may be raised by the garments of the Medes and Assyrians, Virgil is the most ancient writer who expressly mentions the soft wool which was combed from the trees of the Seres or Chinese; and this natural error, less marvellous than the truth, was slowly corrected by the knowledge of a valuable insect, the first artificer of the luxury of nations. That rare and elegant luxury was censured in the age of Tiberius by the gravest of the Romans. Two hundred years after the age of Pliny, the use of pure, or even of mixed silks was confined to the female sex, and all the opulent citizens of Rome and the provinces were insensibly familiarized with the example of Heliogabalus, the first who, by this effeminate habit, had sullied the dignity of an emperor and a man. Aurelian complained that a pound of silk was sold at Rome for twelve ounces of gold; but the supply increased with the demand, and the price diminished with the supply.

"As silk became of indispensable use, the Emperor Justinian saw with concern that the Persians had occupied by land and sea the monopoly of this important supply, and that the wealth of his subjects was continually drained by a nation of enemies and idolaters. An active government would have restored the trade of Egypt and the navigation of the Red Sea, which had decayed with the prosperity of the Empire; and the Roman vessels might have sailed, for the purchase of silk, to the ports of Ceylon, of Malacca, or

Peloponnesus, and it gave to this part of Greece the modern name of *Morea*. From thence the mulberry and the silkworm passed into Sicily, by the care of King Roger, and acquired in Calabria a rapid extension. Some gentlemen who had accompanied Charles the Eighth into Italy during the war of 1494, having discovered all the advantages which that country drew from this branch of agriculture, were

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even of China. Justinian embraced a more humble expedient, and solicited the aid of his Christian allies, Ethiopians of Abyssinia, who had recently acquired the arts of navigation, the spirit of trade, and the seaport of Adulis, still decorated with the trophies of a Grecian conqueror. Along the African coast, they penetrated to the Equator in search of gold, emeralds, and aromatics; but they wisely declined an unequal competition, in which they must be always prevented by the vicinity of the Persians to the markets of India; and the Emperor submitted to the disappointment, till his wishes were gratified by an unexpected event. The gospel had been preached to the Indians; a bishop already governed the Christians of St. Thomas, on the pepper coast of Malabar; a church was planted in Ceylon, and the missionaries pursued the footsteps of commerce to the extremities of Asia. Two Persian monks had long resided in China, perhaps in the royal city of Nankin, the seat of a monarch addicted to foreign superstitions, and who actually received an embassy from the isle of Ceylon. Amidst their pious occupations, they viewed with a curious eye the common dress of the Chinese, the manufactures of silk, and the myriads of silkworms, whose education, either on trees or in houses, had once been considered as the labour of queens. They soon discovered that it was impracticable to transport the short-lived insect, but that in the eggs a numerous progeny might be preserved and multiplied in a distant climate. Religion or interest had more power over the Persian monks than the love of their country. After a long journey they arrived at Constantinople, imparted their project to the Emperor, and were liberally encouraged by the gifts and promises of Justinian. To the historians of that prince, a campaign at the foot of Mount Caucasus has seemed more deserving of a minute relation than the labours of these missionaries of commerce, who again entered China, deceived a jealous people by concealing the eggs of the silkworm in a hollow cane, and returned in triumph with the spoils of the East. Under their direction, the eggs were hatched at the proper season by the artificial heat of dung; the worms were fed with mulberry leaves; they lived and laboured in a foreign climate; a sufficient number of butterflies was saved to propagate the race, and trees were planted to supply the nourishment of the rising generations. Experience and reflection corrected the errors of a new attempt, and the Sogdoite ambassadors acknowledged, in the succeeding reign, that the Romans were not inferior to the natives of China in the education of these insects and the manufactures of silk, in which both China and Constantinople have been surpassed by the industry of modern Europe. I am not insensible of the benefits of elegant luxury; yet I reflect with some pain, that if the importers of silk had introduced the art of printing, already practised by the Chinese, the comedies of Menander and the entire decades of Livy would have been perpetuated in the editions of the sixth century. A larger view of the globe might at least have promoted the improvement of speculative science, but the Christian geography was forcibly extracted from texts of Scripture, and the study of nature was the surest symptom of an unbelieving mind. The orthodox faith confined the habitable world to *one* temperate zone, and represented the earth as an oblong surface, four hundred days' journey in length, two hundred in breadth, encompassed by the ocean, and covered by the solid crystal of the firmament."—*Decline and Fall*, vol. vi.

desirous of conferring the gift on their native country, and so caused the mulberry to be transplanted from Naples into Provence and Dauphiné. It is but thirty years ago when might be seen still at Allan, near Montelimart, the first of these trees which was planted in France. It was brought there by Guy Pope of St. Auban, lord of Auban. At present, the mulberry covers a great part of the south of France, and is cultivated even in the north.

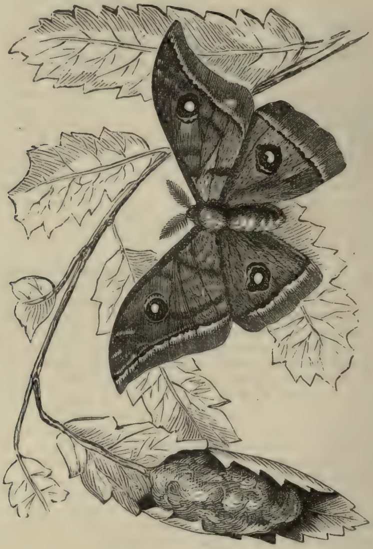

Fig. 450.—China Silkworm.

[The caterpillar of this silk moth or butterfly lives on the leaves of the oak, and on this account attempts are now being made to introduce the species into France and Europe generally. —R. K.]

Silkworms live in the state of a larva about thirty-four days, and during this time change their skin four times;

the time comprised between these successive moultings constitutes what the agriculturalists call the various ages of these little animals. At the approach of each moulting they become as if dormant, and cease to eat; but after having changed their skins their hunger redoubles. They call *petite frèze* the moment of the great appetite which precedes each of the first four moultings, and *grande frèze* that which is observed during the fifth age of the worm. The quantity of nourishment which they consume increases rapidly. It is reckoned that for the larvæ springing from an ounce of seed, seven pounds of leaves are required during the first age, the duration of which is five days; twenty-one pounds during the second age, which continues only four days; seventy pounds for the third age, which lasts seven days; two hundred and ten pounds during the fourth age, which continues seven days; and from twelve to thirteen hundred pounds during the fifth age. It is on the sixth day of the last age that the *grande frèze* takes place. The worms devour then from two to three hundred pounds of leaves, and cause, whilst eating, a noise like a heavy shower of rain. The second day they cease to eat, and prepare themselves to undergo the first metamorphosis. They may be seen then to climb the branches of small faggots placed intentionally and carefully above the hurdles in which they had hitherto remained. Their bodies become soft, and there springs from their mouth a thread of silk which they draw after them. Soon they fix themselves, throwing around them a multitude of threads of extreme fineness, called *banc* or *banne*, and, suspended in the middle of this network, spin their cocoon, which they construct by continually turning on themselves in different ways, and thus rolling around their body the thread which leaves the winder with which their lip is pierced. The thread thus formed is produced by glands which have much analogy with the salivary glands of other animals, and the matter of which it is composed is soft and viscous at the moment of its leaving the mouth, but soon hardens in the air. From this it results that the different turns of this single thread become agglutinated together, and form an envelope whose tissue is firm, and whose shape is ovoid. The colour of this silk varies; sometimes it is yellow, sometimes pure white, according to the variety of the worm which has produced it, and the length of each thread often exceeds six hundred metres, (somewhat more than six hundred yards), but it varies much, as well as the weight of the cocoons. The worms produced from a single ounce of seed may produce as much as one

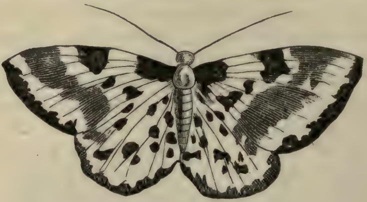

Fig. 451.—Abraxas grossulanata.

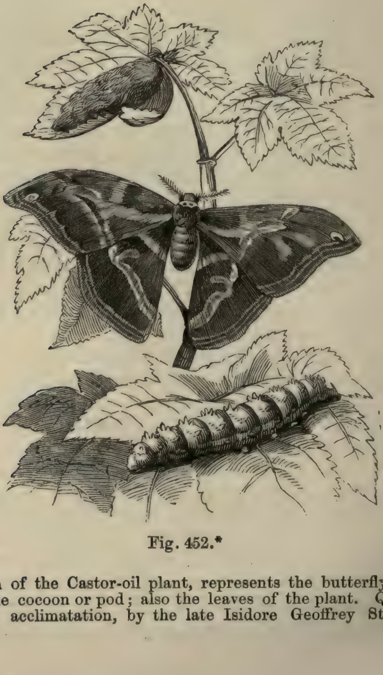

Fig. 452.*

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* Silkworm of the Castor-oil plant, represents the butterfly, the caterpillar, and the cocoon or pod; also the leaves of the plant. Quoted from the work on acclimatation, by the late Isidore Geoffrey St. Hilaire.—R. K.

hundred and thirty pounds, but such a harvest is rare, and often they obtain only from seventy to eighty pounds from the cocoons.

In general, from three days and a half to four days suffice for the larvæ to finish their cocoon, and if we afterwards open this kind of cellule we may see that the animal (Fig. 455) no longer offers the same appearance as before its seclusion; it has acquired a brown colour, its skin resembles old leather, and its form is ovoid, a little pointed at its posterior extremity. Neither head nor jaws are to be any longer distinguished, but its posterior portion is occupied by moveable rings, whilst anteriorly an oblique band may be observed, disposed like a scarf, and representing the future rings of the

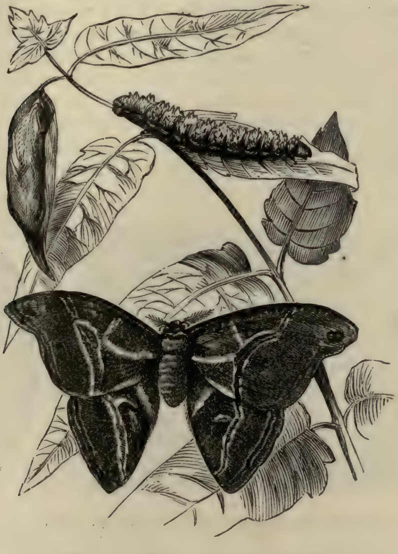

Fig. 453.—Silkworm of the Ailantus.*

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* Silkworm of the Ailantus from India and the extreme East. All these various kinds of silks have their peculiar qualities or properties.—R. K.

perfect animal. The time during which the bombyces remain thus shut up in a state of chrysalis, varies according to the temperature. If the heat be from 15° to 18° (from 59° to 65° Fahrenheit), they come out in the perfect state from the eighteenth to the twentieth day. To pierce their cocoon, they moisten one extremity with a particular liquid which they disgorge, and afterwards they strike their heads violently against the point thus softened. When the bombyx has in this manner finished its metamorphoses, it appears under the form of a butterfly with whitish wings (Fig. 454); its mouth is no longer armed with jaws as when young, but is prolonged into a proboscis rolled into a spiral; its limbs are slender and elongated, and its internal conformation differs as much from that of the larva as its external form. Soon after their birth the papillons seek each other; afterwards the females lay their eggs, the number of which amounts to more than five hundred for each of these insects; finally, after having lived in the perfect state from ten to twenty days, they die.

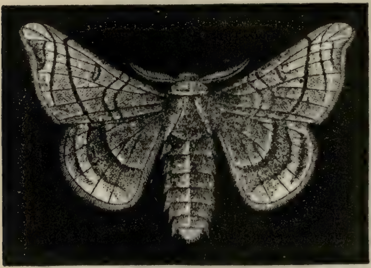

Fig. 454.—Bombyx, or Moth of the Mulberry.

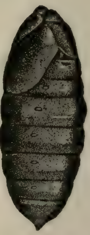

Fig. 455.—Chrysalis of this moth.

§ 533. The bees, of which we have already had occasion to speak (§ 332), experience changes still greater, since in the larva state they have no limbs, and resemble little worms. It is the same with flies, gnats, and a great number of other insects; thus the vermiform animals which swarm in putrid flesh, and which are known by the common name of maggots, are nothing else but the larvæ of the golden fly. Gnats, which at night vault in the air in numerous groups, and which are so harassing to man by their envenomed sting, live in water whilst in their larva state. They are then vermiform, without limbs, and have the abdomen terminated by bristles and appendages disposed in rays (Fig. 456); finally, the last ring but one gives origin to a tube sufficiently long (*t*), by means of which the animal draws from the atmosphere the air it requires. To breathe in this way, it suspends itself as it were to the surface of the water, with the head downwards, and we see it at short intervals renew its arrangement. The *nymph* continues to live in water and to move in it, but instead of breathing like the larva, it obtains the air which it requires through the medium of two tubes placed under the thorax. It floats on the surface of the liquid, and after having accomplished its metamorphoses, the perfect insect (Fig. 457) employs its cast-off covering whilst a nymph as a barge or boat, until its long limbs and wings have acquired sufficient solidity to permit it to walk on the surface of the water or to fly away; for if its body happened to be submerged, as occurs often when the wind upsets its frail embarkation, it would infallibly be drowned.

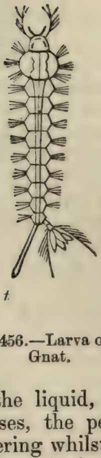

Fig. 456.—Larva of the Gnat.

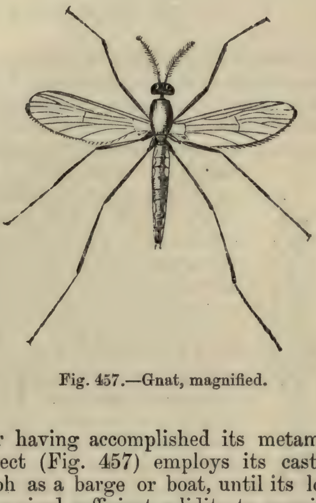

Fig. 457.—Gnat, magnified.

§ 534. The insects which undergo a semi-metamorphosis, also pass through the state of larva and nymph before arriving at their perfect state; but here the larva differs only from the perfect insect by the absence of wings, and the state of nymph is only characterized by the growth of these organs, which, at first folded and concealed under the skin, become then free, but acquire all their development only at the epoch of their last moulting.

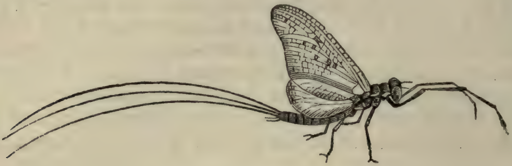

Fig. 458.—Ephemera; Day-fly.

We may cite as examples of insects presenting this kind of metamorphoses the grasshopper and the ephemera (Fig. 458). These last present even a remarkable peculiarity; for in general insects change their skin for the last time when they pass from the stage of nymph to their perfect state, whilst the ephemera experiences another moulting before becoming completely adult, although in this state it lives but a few hours. The larva of this ephemera lives in water, and differs but little from the adult, excepting in the shortness of its limbs, the absence of wings, and by the row of laminæ or plates which it has on each side of the abdomen, and which it employs as organs of respiration and of swimming. The nymph (Fig. 459) only differs from the larva by the presence of sheaths enclosing the wings. At the moment when these organs are to be developed, the insect quits the water, and after having vaulted in the air for some minutes, proceeds to rest upon an elevated object, when it abandons itself to violent movements, by means of which it throws off its tegumentary membrane; it is then only that its limbs acquire all their length, and its body the colours it is afterwards to preserve.

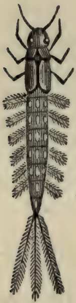

Fig. 459.

§ 535. Some insects, although they undergo considerable changes when young, do not pass through the complete series of transformations of which we have just spoken; they seem, as it were, to stop *en route*, and never come to possess wings. Fleas are in this case, and, leaving the egg, they have no feet, and have the form of small worms, of a whitish colour. These larvæ are very lively, and roll themselves into a circle or spiral. Soon they become reddish, and after having lived in this state a dozen days, they shut themselves up in a small silky cocoon of extreme fineness, to be transformed into a nymph; then, at the end of about twelve days of seclusion, if the time be warm, they leave the envelope in the perfect state.

§ 536. Finally, there are also insects which do not undergo a metamorphosis, and which are born with all the organs they are ultimately to possess; but it is always the apterous insects which offer us this mode of development. The podurella (Fig. 430), already spoken of, and the louse (Fig. 491) offer examples of this.

§ 537. Insects, so remarkable by their organization, are still more so by their habits, and by the admirable instinct which nature has bestowed on so many of them. The artifices they employ to procure their food, or to withdraw themselves from their enemies, and the industry they display in their labours, astonish all who have witnessed them; and when we see them unite into numerous societies, to make up for their individual feebleness, assist each other, divide amongst them the works necessary to the prosperity of their community, provide for their future wants, and frequently even regulate their actions according to the accidental circumstances in which they may be placed, one remains confounded to find, in these beings, so small and apparently so imperfect, instinct so varied and so powerful, and intellectual combinations which so strongly resemble reasoning or judgment. The subject would not become exhausted if we felt inclined to relate here examples of these curious phenomena, but the narrow limits of these lectures do not permit us to consecrate at this moment more time to this subject; and we can only refer our readers to what we have already said whilst treating in a general way of the actions of animals (§ 317 to 339).

§ 538. *Classification of Insects.*—If we now endeavour in a few words to sum up the more important differences which insects present, we shall find that these differences depend especially on the structure of the mouth, which regulates the *régime* of these animals; in the disposition of the organs serving for aërial locomotion, a function which gives to the entire class one of its most prominent characters; finally, on the kind of metamorphoses which these beings undergo when young. Now, after what we have said elsewhere respecting the essence of natural classification, it is evident that it ought in consequence to be in the modifications of the buccal apparatus, of the wings, and of their mode of development, that the zoologist should look for the basis of a methodical distribution of these animals. In fact, it is in this way that they have come to divide them into a certain number of orders, to which have been given the names of *coleoptera, orthoptera, neuroptera, hymenoptera, lepidoptera, hemiptera, diptera, rhipiptera, anoptura, and thysanura.*

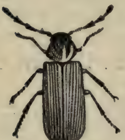

Fig. 460.-Wimble (Ptinus).

§ 539. The coleoptera as well as the orthoptera and the neuroptera, are formed to be nourished on solid substances, whether animal or vegetable, and are furnished for this purpose with mandibles and jaws adapted for the division of this kind of food (Fig. 434). They have two pairs of wings, but those of the first pair are not adapted for flight, and constitute a sort of hard and horny bucklers called elytra (*a*, Fig. 426).

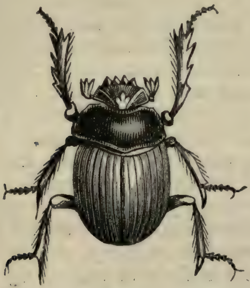

Fig. 461.—Scarabæus (or Alescus), Sacred Beetle of the Egyptians.

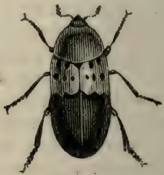

Fig. 462.—Dermeste du Lard; Lard Insect.

The wings of the second pair are, on the contrary, membranous, transparent, and too long to be concealed under the elytra without being folded across; sometimes they are altogether wanting, and then the insect cannot fly; this is the case with the charançon (the weevil) which destroys our granaries, and is remarkable for its head, prolonged into the form of a beak.

The coleoptera undergo complete metamorphoses. The larva resembles a worm with a horny head, whilst the rest of the body is almost always soft (Fig. 463); its mouth is formed in the same way as that of the perfect insect; the three rings which follow the head have each of them almost always a pair of limbs, generally very short; finally, there exists in a great number of these animals a pair of false limbs attached to the last segment of the abdomen. The nymph is inactive, and takes no nourishment; it is covered with a membranous skin, applied exactly over the subjacent parts, and permits their being seen.

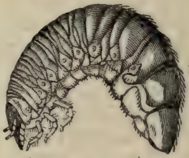
Fig. 463.—Larva of the May-bug, or Cockchafer.

Most of these insects are remarkable for the hardness of their integuments and the brilliancy of their colours. Some are carnivorous,—the gilded carabus (beetle) or gardener (Fig. 9), so common in the sandy walks, for example; others, as the may-bug, live on vegetables. Their number is immense, and already thirty thousand species are known; but we shall limit ourselves here to mentioning only the scarabæi, of which one species (Fig. 461) is celebrated, by reason of the respect with which it was viewed by the ancient Egyptians; the cantharides, or Spanish flies (Fig. 464), which, in the south of France and of Spain, live on the ash-tree and the lilac, and furnish to medicine a very energetic blistering substance; the weevils, which live on grain; the wimble (Fig. 460) (Ptinus), and the wood piercers, which in the state of larva perforate the wood of old furniture and timber-work; the dermestes (Fig. 462), whose larvæ live on the cast-off skins of other animals; and often in this way destroy furriery and zoological collections;

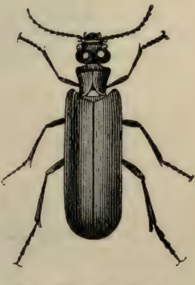
Fig. 464.—Cantharis, or Spanish Fly.

finally, the coccinella or ladybird, the cicindela, the carabus, (Fig. 9), &c.

§ 540. The orthoptera resemble the preceding by the general disposition of the organs of mastication, as well as by the number and consistence of their wings, but are distinguished by the manner in which their posterior wings are folded, and by the nature of their metamorphoses. The elytra are less hard than in the coleoptera, and the membranous wings (Fig. 465) when they are at rest are not folded transversely, but merely longitudinally, in the manner of a fan. They undergo only a semi-metamorphosis, and the larva as well as the nymph resembles a perfect insect, excepting as regards the wings. Finally, all are terrestrial, and most of them are remarkable for the elongation of their body and for the extreme development of their posterior limbs, which makes them leaping animals.

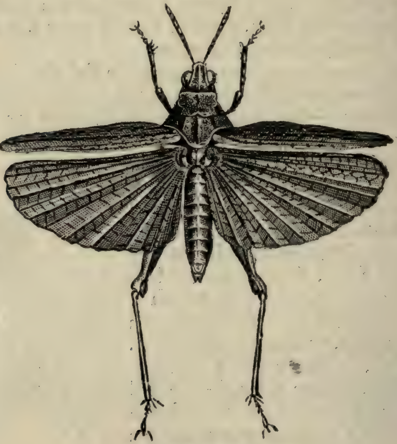

Fig. 465.—Locust.

The locusts and crickets (Fig. 421) are the principal representatives of this group; but in it are also arranged the mantis (Fig. 424), the leaf-insect (Fig. 468), the cricket (Fig. 467), the mole cricket (Fig. 423), the cockroach (Fig. 466), and the forficula (Fig. 429).

§ 541. The neuroptera are distinguished from other masticating insects by the structure of their wings, four in number; these are all membranous, transparent, of extreme delicacy, and of equal utility for flight. The body of such insects is generally soft, and very elongated. Finally, some undergo a complete metamorphosis, others only a semi-metamorphosis. This order comprises the libellulæ (Fig. 469), the agrions (Fig. 171), the ephemera (Fig. 458), the ant-lion (Fig. 115), the phryganidæ, the termites, &c.

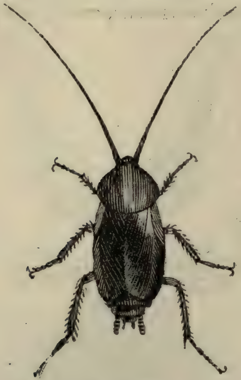

Fig. 466.—Cockroach.

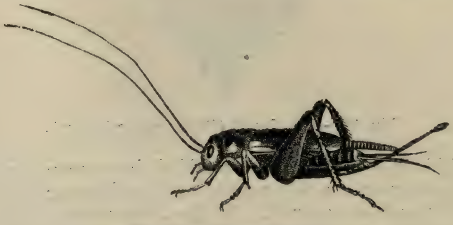

Fig. 467.—House Cricket.

These last insects, known also by the name of white ants, are very destructive; they are met with chiefly in warm countries, but they cause considerable destruction in some parts of France, as at Rochelle and at Rochefort, for example: they destroy the timber of carpenters' work, and live in numerous societies, composed of winged males and females, of wingless neutral individuals, and of the young.

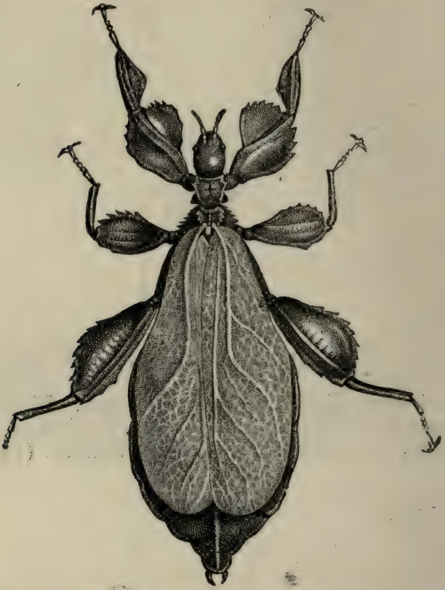

Fig. 468.—Leaf Insect (Phyllium Succifolium).

§ 542. The hymenoptera establish in some measure the passage between masticating and sucking insects: they have in front mandibles very like the first, but which do not serve for mastication, and they are nourished with soft or liquid matters, which they suck up by means of a moveable and flexible proboscis, composed of gums and of the languette extremely elongated (Fig. 436). They have, like the neuroptera, four membranous and transparent wings; but these wings, instead of being reticulated like lace, are divided into a certain number of tolerably large cellules by horny nervures, and they cross each other horizontally on the body during repose. These integuments are not very hard, and the abdomen of the female is terminated by a wimble or dart.

These insects undergo a complete metamorphosis. The larva, sometimes deprived of wings, resembles a worm; at other times, having six feet, with hooks, and often also from twelve to sixteen membranous feet, it more resembles a caterpillar. In both cases it has a scaly head, with mandibles, jaws, and a lip, at the extremity of which is a winder for the passage of the silky matter of which the cocoon is to be constructed. The *régime* of these larvæ varies much. Several require foreign aid, and are brought up in common by sterile individuals, reunited into a society, as we have seen in speaking of bees (§ 332). The nymph remains without nourishment, and in complete repose. Finally, in their perfect state, the hymenoptera live almost all on flowers, and they die at the end of the first year of their existence.

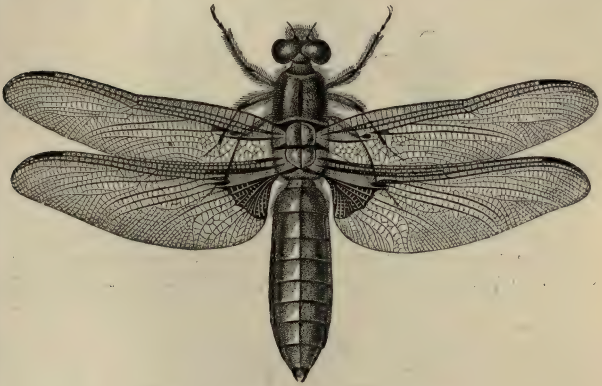

Fig. 469.—Dragon Fly (Libellula depressa).

This order comprises most of the insects more remarkable for their instincts, such as ants, bees (Fig. 131), and wasps; to it also belong the humble bee (Fig. 131), the xylocopes (Fig.

124), the tenthredes, the sirex (Fig. 474), the ichneumon, the cynips, &c.

§ 543. The order of lepidoptera is composed of insects whose mouth (Fig. 441) is so formed as to be adapted only for the drawing up of juices deposited on the surface of plants; whose wings are four in number, membranous, as in the two preceding groups, opaque, and variously coloured by the presence of a sort of scaly dust fixed to the surface. The mouth, as we have already said, has the form of a proboscis rolled into a spiral. Finally, these insects undergo a

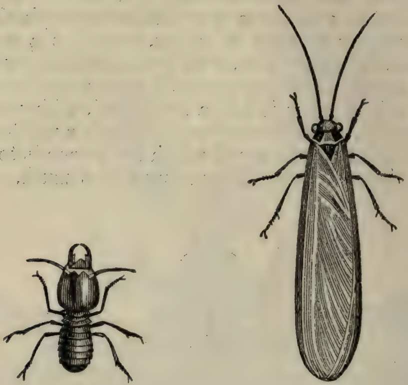

Fig. 470.—Termites (White Ants).

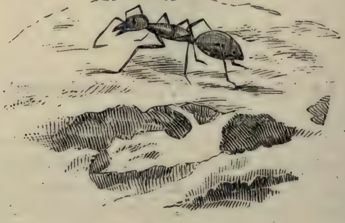

Fig. 471.—Ant.

complete metamorphosis, and their larvæ (Figs. 446, 449, 479, 4*b*), known by the name of caterpillars, are provided with feet towards the two extremities of their body, and live generally on leaves; some envelope themselves in a silky cocoon in order to complete their transformation; others roll themselves into leaves, or suspend themselves to some foreign body by means of a silken thread.

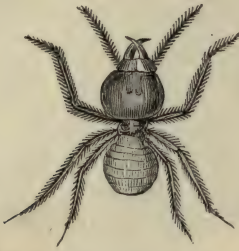

Fig. 472.—The Bashikouay Ant.

[This ant, also called *Nchounou* by the Mpongwe, is very abundant in the whole region I travelled over in Africa, and is the most voracious creature I ever met. It is the dread of all living animals, from the leopard to the smallest insect. I do not think that they build a nest or home of any kind. At any rate, they carry nothing away, but eat all their prey on the spot. It is their habit to march through the forests in a long, regular line —a line about two inches broad, and often several miles in length. The bashikouay have the sense of smell finely developed. They are longer than any American ant, being at least half an inch long, and are armed with very powerful fore-legs and sharp jaws, with which they bite. They are red or dark brown in colour.—R. K.]

Amongst the lepidoptera, some fly during the day, others show themselves only at dusk, and others remain as it were benumbed during the day, and appear only at night. The diurnal are known by their wings being elevated vertically during repose (Fig. 476), and are remarkable for the variety and brilliancy of their colours. They are generally termed *papillons* (butterflies), but zoologists divide them into vanessæ (Fig. 475), butterflies, properly so called (Fig. 442), danaïdes (Fig. 476), &c. The twilight and the nocturnal have the wings horizontal during repose, and have in general more sombre colours than the preceding. These are the sphinx (Fig. 477), the silkworm moths (Figs. 454 and 478), the phalænæ, the

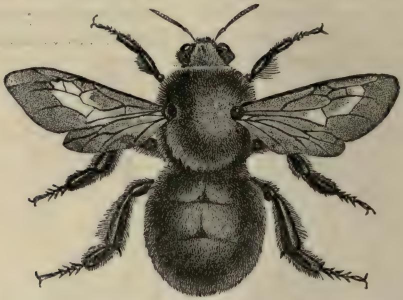

Fig. 473.—Bombus, or Humble Bee (Apis muscorum).

tineite, &c. The pyralis (Fig. 479), which occasions also such destruction to the vineries, belongs to this group.

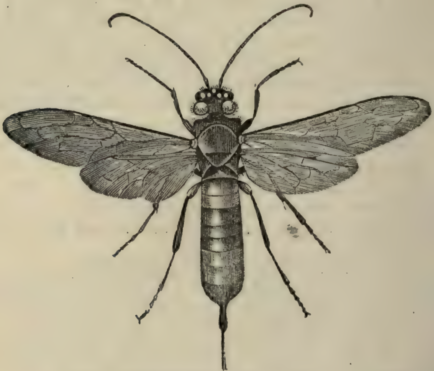

Fig. 474.—Gigantic Sirex (Sirex gigantea).

§ 544. The hemiptera also have the mouth formed for suction, not consisting in a single proboscis, but with the form of a bill or beak, in the interior of which are sharp stylets, adapted to perforate animal or vegetable tissues, in which the animal finds the liquids by which it is nourished

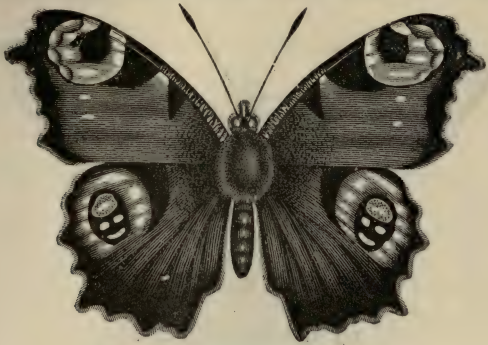

Fig. 475.—Peacock Butterfly (Vanessa io).

(§ 523). These insects have generally four wings, like all the preceding, but usually those of the first pair are only membranous towards the extremity, and constitute semi-elytra.

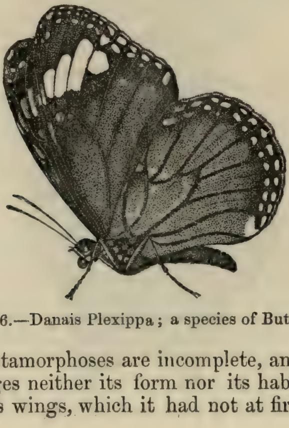

Fig. 476.—Danais Plexippa; a species of Butterfly.

Finally, the metamorphoses are incomplete, and the insect as it grows changes neither its form nor its habits; only it in general acquires wings, which it had not at first; sometimes, however, they remain without these organs. This is the case with the bed bugs, for example. We arrange in this order the pentatoma, the halys or wood bug (Fig. 480 and 481) &c., the nepas or water flea (Fig. 484), the cigale or balm cricket (Fig. 482), the pucerons, the cochineal, &c. We may also bring near to this group the flea (Fig. 483), for

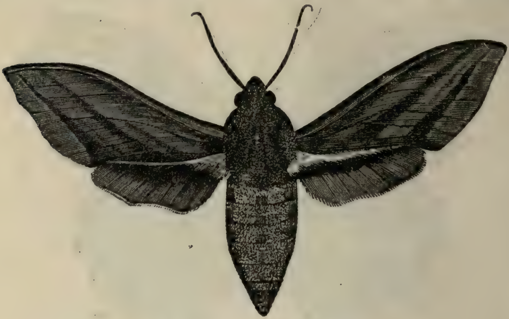

Fig. 477.—Sphinx of the Vine.

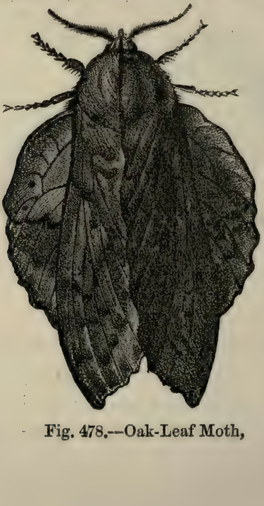

Fig. 478.—Oak-Leaf Moth,

example, which is always apterous, like the bug, and which has been considered by most naturalists entitled to form a particular order, called suckers.

§ 545. The order of diptera is characterized by the existence of a single pair of membranous wings, not unlike those of the hymenoptera, and by the structure of the mouth, arranged for suction only; we observe in it in general a proboscis, sometimes horny and elongated, sometimes soft and retractile, and inclosing stiff and sharp bristles.

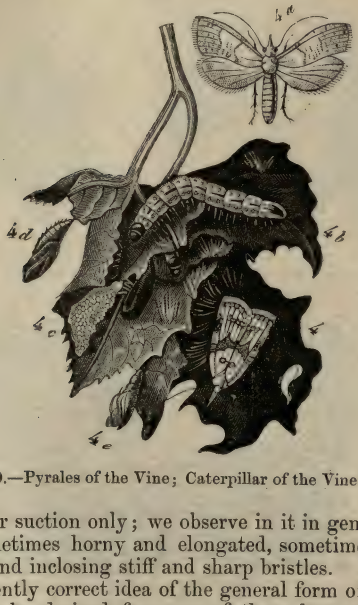

Fig. 479.—Pyrales of the Vine; Caterpillar of the Vine Moth.*

A sufficiently correct idea of the general form of dipterous insects may be derived from one of them known to all the world—the common fly; and we shall only add, that all undergo a complete metamorphosis. The larvæ (Fig. 486, *a*) have no limbs; their head is soft, and the mouth is generally provided with hooks. Sometimes they change the skin several times, and spin a cocoon, to transform themselves in it into a nymph; at other times they do not moult, and their skin, hardened and horny, becomes for the nymph a solid cocoon, having the appearance of a seed (Fig. 486, *a*).

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* Leaf of the vine attacked by the pyrales:—4, the male; 4*a*, the female 4*b*, the caterpillar; 4*c*, the eggs; 4*d* and 4*e*, the chrysalides.

In this division we place, in addition to the flies, properly so called, the gnats, the gad-fly (Fig. 487), the œstrus (Fig. 486), &c.

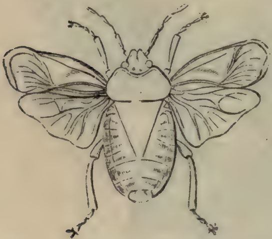

Fig. 480.—Pentatoma (Cimex ornatus).

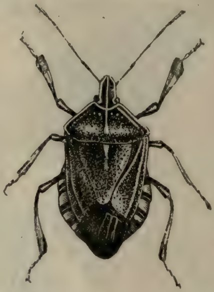

Fig. 481.—Halys, or Wood Bug.

§ 546. The rhipiptera are insects having also but two wings, but in which the organs are folded longitudinally, like a fan; two genera only are known, the stylops (Fig. 490) and the xenos, which in their state of larva live as parasites on the abdomen of wasps and other hymenoptera.

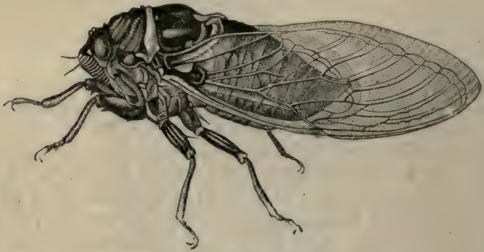

Fig. 482.—The Balm Cricket.

§ 547. The order anoplures or parasites is not numerous, and is composed of insects which are always without wings, which have the mouth arranged for suction, and which do not undergo a metamorphosis. As indicated by their name, they live on the bodies of other animals, whose veins they suck. They form two genera, the pediculus (Fig. 491), and

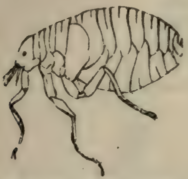

Fig. 483.—The Flea.

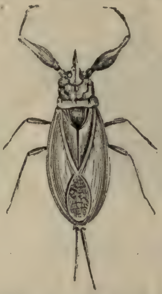

Fig. 484.—The Nepa. Water Scorpion.

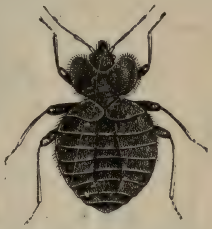

Fig. 485.—The Bug.

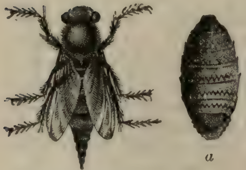

Fig. 486.—Œstrus, or Bat-fly.

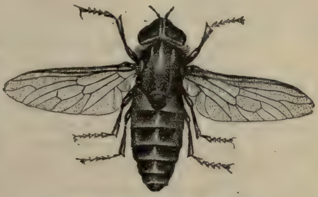

Fig. 487.—The Ox-fly, or Gad-fly.

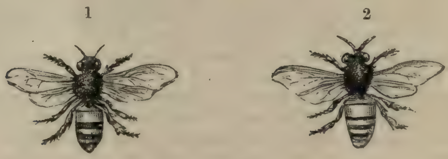

Fig. 488.*

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* 1. The Ligurian Bee (apis ligustrica); 2. the Banded Bee (apis fasciata); described by M. Isidore Geoffroy St. Hilaire.—R. K.

the riccinus; these last attach themselves to the dog and to various birds.

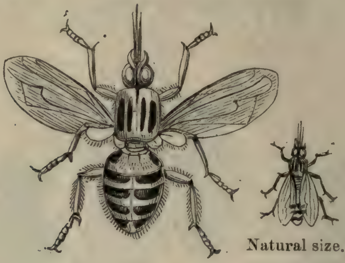
Natural size.

Fig. 489.—The Tsetse-fly.

[The tsetse fly; copied from Dr. Livingstone's work on South Africa, p. 571. The following interesting account of this remarkably destructive fly is taken from the work of the celebrated traveller alluded to.

"The tsetse is not much larger than the common house-fly, and is nearly of the same brown colour as the common honey-bee; the after part of the body has three or four yellow bars across it; the wings project beyond this part considerably, and it is remarkably alert, avoiding most dexterously all attempts to capture it with the hand at common temperatures; in the cool of the morning and evening it is less agile. Its peculiar buzz, when once heard, can never be forgotten by the traveller whose means of locomotion are domestic animals; for it is well known that the bite of this poisonous insect is certain death to the ox, horse, and dog. In this journey, though we were not aware of any great number having at any time lighted on our cattle, we lost forty-three fine oxen by its bite. We watched the animals carefully, and believe that not a score of flies were ever upon them. A most remarkable feature in the bite of the tsetse is its perfect harmlessness in man and wild animals, and even calves, so long as they continue to suck the cows. We never experienced the slightest injury from them ourselves, personally, although we lived two months in their *habitat*, which was in this case as sharply defined as in many others, for the south bank of the Chobe was infested by them, and the northern bank, where our cattle were placed, only fifty yards distant, contained not a single specimen. This was the more remarkable, as we often saw natives carrying over raw meat to the opposite bank with many tsetse settled upon it."

The history of this singular and most destructive insect cannot fail to excite deep reflections in the mind of the reader, as showing by what apparently insignificant means, entire races of valuable animals may be destroyed. Many wild species of the equine family and of the buffalo exist in Southern Africa, and live with impunity, unscathed by the tsetse, the attacks of which prove so fatal to certain domestic animals. The ass, though domestic in a sense, is not injured by the tsetse ; so also with the buffalo, and seemingly all the species of antelope. Sheep also are safe from its attacks.—R. K.]

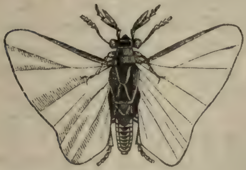

Fig. 490.—Stylops.

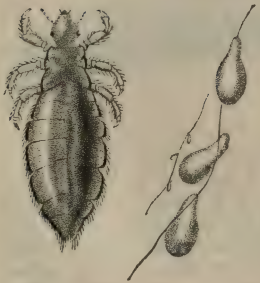

Fig. 491.—Pediculus humanus, or Louse.

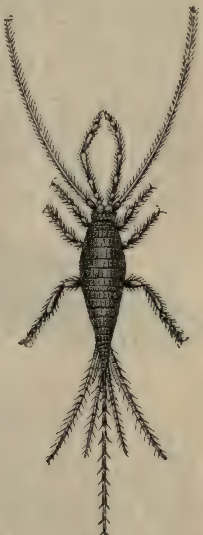

Fig. 492.—Machilis.

§ 548. Finally, the insects of the order thysanura commence equally with the form which they preserve through life, and are always without wings ; but they are distinguished from the preceding by their masticatory apparatus, and by the appendages with which their abdomen is provided. These are the podurellæ (Fig. 430), the lepisma, machilis (Fig. 592), &c.

CLASS OF THE MYRIAPODA.

§ 549. The myriapoda (many feet) respire air by means of tracheæ, like insects, but they differ considerably from these animals, as well as from the arachnides (spiders), by their general conformation. Not only they never have wings, but their body, much elongated and divided into a great number of rings, carries on each of these segments at least a pair of limbs, besides the number of these organs, always twenty-four at least, or more; nor is there any line of demarcation between the thorax and the abdomen. They somewhat resemble serpents, or worms with feet; but their internal organization brings them nearer to ordinary insects, excepting that their circulatory system is much less incomplete.

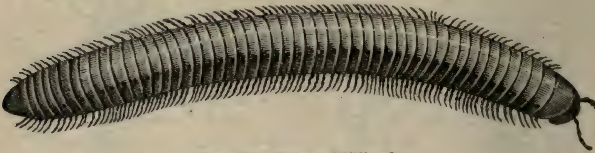

Fig. 493.—Iulus; Millipede.

The head of the myriapoda is provided with two small antennæ, and with two eyes, generally formed by the reunion of ocelli. Their mouth is formed for mastication, and is provided with a pair of bi-articulated mandibles, followed by a sort of lip with four divisions, and with two pairs of appendages resembling little feet. The number of the rings of their bodies varies, and sometimes these segments appear re-united, two and two, in such a way that each moveable segment carries two pairs of limbs (Fig. 493). These last organs terminate only in a single hook. Finally, there exists on either side of the body a series of stigmata, in communication with tracheæ, formed in the same way as those of ordinary insects. The myriapoda experience metamorphoses in youth, but these changes are not analogous to those we have seen take place in insects properly so called, and consist only in the formation of new rings, and in a corresponding augmentation in the number of the limbs.

§ 550. Two natural groups, easily distinguished by the form of the antennæ, compose this latter class—namely, the chilognathus or iulus, and the chilopodes or scolopendra.

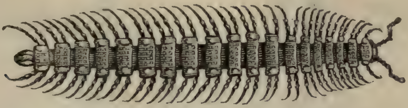

Fig. 494.—Polydesmus, Lat. Iulus complanatus, Fab. Flattened millipede.

The chilognathi have a cylindrical body, and feed on organic matters more or less decomposed; their pace is slow, and they often roll themselves into a spiral or ball. They are known by the names of iulus (Fig. 493), polydesmus (Fig. 494), and of glomeris.

The chilopoda have the body flattened and more membranous than the preceding; they are carnivorous, and run very fast. Three principal genera compose this group: the scolopendra (Fig. 164), the lithobius, and the scutigera.

OF THE CLASS ARACHNIDA.

§ 551. The class of the arachnida is composed of articulated animals, having a strong analogy with insects, and, like them, organized to live in air, but which may be distinguished at once by the general form of the body, and by the number of their limbs; they differ also from those animals in several important particulars as regards their internal structure. In fact, all the arachnida have the head confounded with the thorax, and have no antennæ; they have four pairs of limbs, and never wings; and they breathe in general by means of pulmonary cavities, and have all a tolerably complete circulatory apparatus.

§ 552. The tegumentary skeleton of these animals is in general less solid than that of insects, and their body is composed of two principal parts, almost always distinct; the one called *cephalothorax*, because it is formed by the head and thorax confounded into a single segment; the other named *abdomen*, and composed sometimes of a series of distinct rings, as may be seen in scorpions (Fig. 499); sometimes of a soft mass, globular, and without divisions, as, for example, in spiders (Fig. 495).*

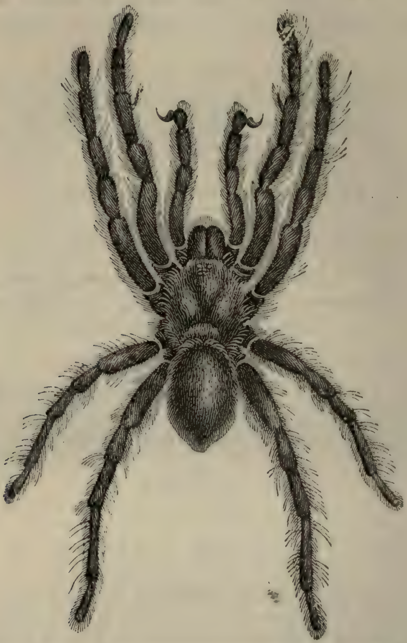

Fig. 495.—Mygale, Cuv. Aranea avicularia, Lin.; Crab Spider.

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* The arachnides are divided into two orders, the pulmonaria and the trachearia. The first includes such genera as the aranea, the tarantula, scorpio, &c. The second order includes the phalangida, with its various orders of siro, trogulus, &c., and the acarus, of which there are many subgenera and species.—R. K.

The organs of locomotion are all fixed to the cephalothorax, and consist of eight pairs, strongly resembling those of insects, and almost always terminated by two hooks; their length is in general considerable, and they easily break; but, as in the crustacea, the stump, after having cicatrised, reproduces a new limb, which increases by little and little, and ends by becoming similar to that of which the animal had been deprived. The arachnida never present even the vestiges of wings, and their abdomen is always completely deprived of locomotive appendages.

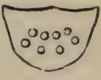

Fig. 496.

§ 553. It is in the anterior part of the cephalothorax that we find the mouth and the eyes. These latter organs are always simple, and in considerable number; we generally find eight of them (Fig. 496), and we observe in each of them a transparent cornea, behind which is a crystalline humour or lens, and a vitreous humour, then a retina, formed by the termination of an optic nerve, and an envelope of colouring matter. We find nothing in respect of the instruments by which the arachnida ascertain the presence of sounds, but we have many proofs of the existence of this sense in these animals, and it would even appear that some of them are sensible to the charms of music. Touch is exercised chiefly by the extremity of the limbs, and by the appendages with which the mouth is provided.

§ 554. The nervous system of the arachnida presents differences sufficiently remarkable; sometimes, as in the scorpions for example, it is composed of a series of nine ganglionary masses, reunited together by double cords of communication, and forming a chain extending from one extremity of the body to the other, and in an almost uniform manner; at other times, as in spiders, &c., we find all the ganglions of the thorax united into a single mass (*t*, Figs. 497 and 500), whence proceed backwards two cords (*c*), which proceed to terminate in a single abdominal ganglion (*a*, Fig, 500). Further, the general disposition of these parts is always the same; the anterior ganglions (*c*), situated in front of and above the gullet, and considered most generally as representing the brain of these animals, give origin to the optic nerves anteriorly, and are continuous behind with the œsophagal collar; the other ganglions are situated under the alimentary tube, and send nerves to the limbs, abdomen, &c.

§ 555. The arachnida are carnivorous, but confine themselves generally to suck the humours contained in the dead body of their victim; and in order to render easy the capture of animals whose strength they might dread, nature has provided a great many of them with a venomous apparatus. Most of them feed on insects, which they seize alive; some, however, are parasites. In the first, the mouth (Fig. 498) is furnished with a pair of mandibles, armed with moveable hooks, or formed like forceps of a pair of lamellated jaws, having each a large feeler more or less pediform, and some of a lower lip; in the parasite arachnida, the mouth has the form of a small proboscis, whence springs a kind of lancet formed by the jaws.

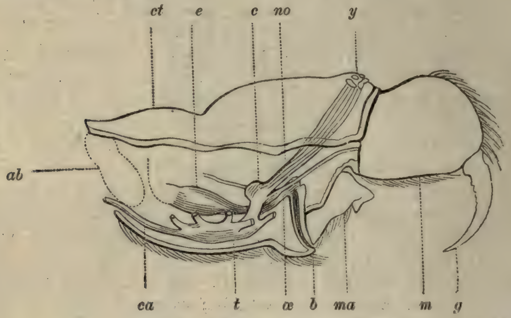

Fig. 497.—Nervous System, &c.*

The moveable hook or claw of the mandibles has near its extremity a small opening, which is the orifice of the excretory canal of the venomous gland already spoken of, and the liquid which it pours into the bottom of the wound causes immediately the benumbing of the insects which these animals pursue, but is too feeble to injure man, and it is without any reason that the common people often ascribe to the bite of spiders the pimples and red spots which sometimes appear on the skin.

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[*] Section of the cephalothorax of the Mygale (crab spider), showing the disposition of the nervous system :—*ct*, cephalothorax; *m*, mandible; *g*, claw or moveable hook terminating it; *b*, mouth; *œ*, the gullet; *e*, the stomach; *ab*, origin of the abdomen; *c*, brain or cephalic ganglion; *t*, ganglionary mass of the thorax; *ca*, cords uniting the abdominal ganglions; *no*, optic nerve; *y*, the eyes.

Certain arachnida are provided with another venomous apparatus destined for the same purpose, and also serving as defensive weapons,—such as the hook or claw which terminates the abdomen of scorpions (Fig. 499). This sting presents underneath the point several openings which communicate with the venomous glands, and the sting of these arachnida is often mortal, even to animals of considerable size, as the dog. The great scorpions of hot countries are also much dreaded by man, but the sting of the species inhabiting Europe would seem never to be mortal; there generally arises a local inflammation, more or less acute, accompanied with fever and stupor, sometimes vomitings and tremblings, as the result of such a wound. To overcome these symptoms, medical men recommend the use of volatile alkali, given internally as well as applied externally to the wound; emollient substances are also applied to the wound.†

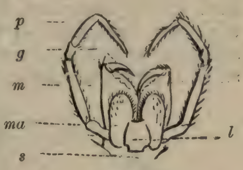

Fig. 498.*

The intestinal canal is in general very simple, but is sometimes complicated, with cæcal appendages which penetrate even into the interior of the limbs.

In general, tubes analogous to the biliary vessels of insects open into the intestines near the anus; but in some arachnida, such as scorpions, there exists also a liver, composed of four glandular branches.‡

It is also around the anal opening that we find the secreting glands of the silky matter, and the winders by the aid of which several arachnida construct webs, which are often of great extent and of extreme fineness (Fig. 500).

§ 556. The respiration of the arachnida is aërian, and takes place sometimes by means of tracheæ; but in most of these animals, especially in spiders and scorpions, it is concentrated in pouches lodged in the abdomen, and called lungs. These latter organs present internally a number of membranous lamellæ (*l*, Fig. 500), arranged like the leaves of a book; thus, they more resemble branchiæ than true lungs. Each lung receives the air by an opening situated in the lower aspect of the abdomen (*s*), and sometimes two such may be counted, sometimes four, and sometimes eight.

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* Buccal apparatus of a spider:—*s*, the sternum; *l*, the lip; *ma*, jaws; *p*, palpi of the jaws; *m*, mandibles; *g*, hooks or claws of the mandibles.

† In Southern Africa, and on the banks of the Great Fish River, I observed a small black spider, whose sting produced the symptoms described in the text, even in the adult; but in none of the cases which I met with did they prove fatal. The remedies I applied were the volatile alkali and strong spirits.—R. K.

‡ These animals are numerous beyond imagination in Southern Africa, on the banks of the Great Fish River. I remember a large plain covered with small flat loose stones, underneath each of which there seemed to reside a scorpion; for of the hundreds turned over, we never failed to find one. They were also always solitary. This was at the post of Wenzel Koosters.—R. K.

Certain spiders possess at the same time lungs and tracheæ, such as the segestries;* and others, as the faucheur and the mites, have tracheæ only. These tubes have the same structure as in insects, and the air enters them by two very small stigmata situated at the lower part of the abdomen.

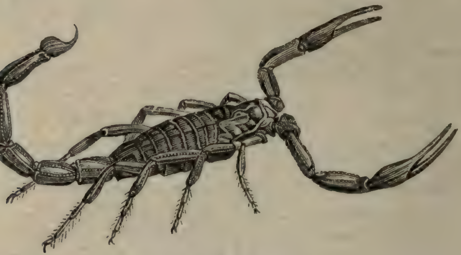

Fig. 499.—The Scorpion.

The blood is white in all animals of this class. The pulmonary arachnida have a circulatory apparatus sufficiently complete. Their heart (Fig. 501), situated in the back, has the form of an elongated vessel, and gives origin to various arteries; the blood, after having traversed the organs, proceeds to the lungs, and from thence reaches the heart, following a course similar to that which we have already seen takes place in the crustacea (§ 111). In the arachnida which breathe only by tracheæ, the apparatus of the circulation is rudimentary. There appears to be merely a simple dorsal vessel without arteries or veins.

§ 557. The arachnida lay eggs like insects, and the male differs generally from the female in the form of the maxillary feelers, the uses of which appear to be very important. A great number of these animals envelope their eggs in a cocoon of silk, and sometimes the mother remains near her young family to protect it, and even carries the little ones on her back when they are too feeble to walk alone. All these animals undergo several moultings before reaching the adult age, and some experience a sort of metamorphosis; for there are of them whose limbs at first are only three pairs in number, but which acquire a fourth at a more advanced age.

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* Sub-genus segestria, Lat. Example of species: Aranea florentina, Ross.—R. K.

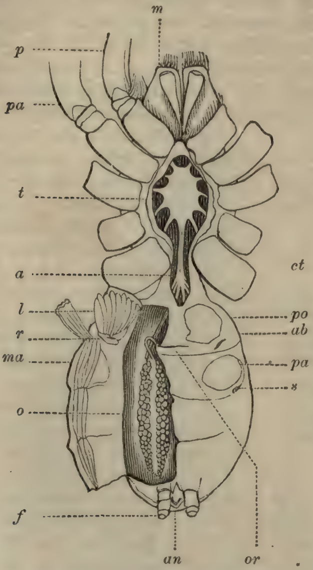

Fig. 500.—Anatomy of a Mygale.*

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* [Aranea avicularia: Crab Spiders. I have seen them very large in South Africa.—R. K.] *ct*, cephalothorax open below, and giving attachment to the limbs, the base of which is in place; *pa*, limb of the first pair; *p*, feeler; *m*, mandibles; *ab*, abdomen; *t*, thoracic ganglionary mass; *a*, abdominal ganglions; *po*, pulmonary pouches; *s*, stigmata; *l*, respiratory lamellæ of one of its cavities, laid open; *o*, the ovaries; *or*, orifice of the oviducts; *ma*, muscles of the abdomen; *an*, anus; *f*, spinnerets.

§ 558. The arachnida have varied instincts no less remarkable than those of insects; and one feels inclined to accord to them still higher faculties, for animals of this class have been seen capable of a kind of education, and to give signs of a sort of intelligence. Many amongst them have recourse to particular tricks to secure their prey, and others display in the construction of their dwelling a singular industry. We have already had occasion to speak of the remarkable nest of the mygale (Fig. 120); the webs which the garden spiders stretch with an admirable regularity are equally curious. The silk with which these animals thus construct their retreats, stretch snares for their prey, and form cocoons for their eggs, is secreted by an apparatus lodged in the posterior part of the abdomen. This apparatus consists in several packets of vessels, turned on themselves, and terminating in pieces pierced at the summit of four or six conical or cylindrical mamelons called winders, and situated under the anus (Fig. 500). The gluey matter expelled through these pores acquires consistence by the contact of the air, and forms threads of extreme tenuity, and of a very great length. By the aid of its limbs the animal reunites into a single cord a multitude of these threads, and each time that, in balancing itself, these winders come to touch the body on which it rests, they attach to it the extremity of one of these threads, the opposite end of which is still enclosed in the secretory apparatus, and the length of which it may consequently augment at pleasure. The colour and the diameter of the thread, varies much: a spider of Mexico constructs a web composed of red, yellow, and black threads, interlaced with remarkable art; and it has been calculated that ten thousand threads, as they come from the pores of one of the winders of some of our common spiders, do not equal in thickness one of our hairs; whilst other species, peculiar to hot countries, form nets so strong that they suffice to arrest the progress

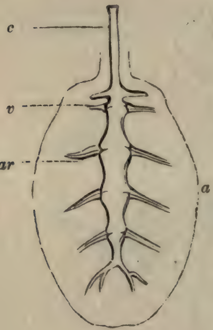

Fig. 501.*

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* Abdomen and Heart of a Spider:—*a*, abdomen; *c*, heart; *ar*, cephalic artery; *v*, venous canals.

of small birds, and even man himself is obliged to make an effort to break through them. The manner in which spiders arrange their silk is no less varied: some confine themselves to stretch irregular threads, and others weave a web the meshes of which are of extreme regularity. Sometimes we see them immovable in the middle of their web, watching their prey; at other times, they conceal themselves in a retreat which they construct at hand, and which sometimes has the appearance of a silky tube, sometimes that of a small cup or cupola.

§ 559. The arachnida are divided into two orders, according to the structure of the organs of respiration and of circulation.

The arachnida pulmonaria are chiefly characterized by the presence of pulmonary pouches and of a well developed vascular apparatus; but they may also be recognised by other peculiarities of structure. Thus, their eyes are six, eight, or even more in number, and under the abdomen may be seen two, four, or eight stigmata. Moreover, the general form of these animals varies. Sometimes they have the abdomen globular, winders at its extremity, and small mandibular feelers; at other times the abdomen is elongated and composed of several rings; their mandibular feelers advance like arms, and terminate like forceps; or finally, there exist no winders at the extremity of the body, but in general a venomous apparatus. Spiders properly so called (Fig. 174), that is to say, the mygale (Fig. 495), the epeira, the lycosæ or tarantulæ, the theridions (Fig. 502), present us with the first of these two modes of conformation; the scorpion (Fig. 499), the second.

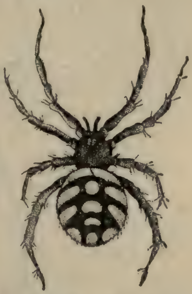
Fig. 502.—Theridion malmignathe.

§ 560. The arachnida trachearia have no pulmonary pouches, but respire by tracheæ, like insects, and have only a rudimentary vascular apparatus for the circulation of the blood. Some are without eyes, and in those which have them, we never find more than two or four. Some of these animals, known by the name of faucheurs, greatly resemble spiders, and are remarkable for the length of their limbs; others have the mouth formed for suction, and constitute the family acari or mites; they are very small, and several live as parasites on other animals. One species, the ixodes of Brazil, fixes itself on dogs, oxen, &c., and so deeply plunges its suckers into the flesh of these animals, that they cannot be detached without raising up the portion of the skin to which they adhere. It is asserted that the multiplication of these parasites is sometimes so considerable as to cause the death of the oxen and horses to which they have fixed themselves, by exhaustion.* Another kind of mite, called *leptus autumnalis*, or *rouget*, is very common in the autumn in our fields, and, insinuating itself under the skin of the legs, causes insupportable itchings. Finally, it is a small animal of this family which, by multiplying in winding burrows under the skin, occasions one of the most disgusting diseases, the Psora, or Itch. The sarcopt of the Psora (Fig. 503) is scarcely visible to the naked eye; but when examined with a microscope, its body is seen to be oblong, and its mouth to

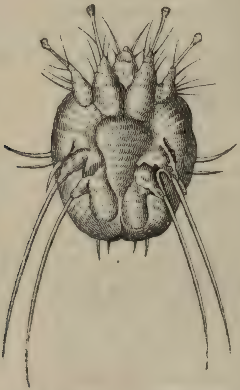

Fig. 503.—Sarcopt of the Psora (magnified); Itch Insect.

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* Parasitical animals of this class abound in Southern Africa, and I am aware that they attach themselves indiscriminately to oxen, horses, dogs, &c., but it seemed to me that they had a predilection for the diseased or enfeebled animal; for if by chance an exhausted horse was left on the field for some days, he became covered with these vermin, whilst they seldom attached themselves to the healthy, well-fed animal.—R. K.

have the form of a conical papilla armed with several bristles, and its feet, eight in number, differ very much from each other, the four posterior feet being terminated only by bristles, whilst the four anterior feet are furnished at their extremity with small suckers, by means of which they can adhere to the most polished bodies.

CLASS OF CRUSTACEA.

§ 561. The crustacea are articulated animals properly so called, having the respiration branchial or only cutaneous, and a circulatory apparatus semi-vascular and semi-lacunar. The crabs, craw-fish, and lobsters (Fig. 504), form the type of this group, but naturalists arrange in it also a great number of animals whose structure is much less complex, and whose external form is different; for in proportion as we descend in the natural series of these animals, we find the general plan of organization to be successively modified and simplified more and more. The lowest of the crustacea are even so imperfect, that they can only live when fixed as parasites on other animals, and most naturalists have arranged them with the intestinal worms.

§ 562. The tegumentary skeleton of the crustacea presents in general a very considerable consistence. It has almost always a stony hardness, and encloses, in fact, a considerable portion of the carbonate of lime. One may view this solid envelope as being a kind of epidermis, for beneath it we find a membrane (*t*, Fig. 513) resembling the dermis of superior animals; and at certain points the hard calcareous envelope is detached and thrown off, as we have already seen the epidermis of reptiles separate itself from the body, and the tegumentary membrane of the larvæ of insects moulting or renewing itself several times. It is easy to understand the necessity of these moultings in animals whose whole body is enclosed in a solid case, which, as it cannot grow proportionately with the interior structures, would present insurmountable obstacles to their development if it did not fall or was thrown off at the moment when it became too small to lodge the body conveniently; thus the crustacea change their external covering during the entire period of their growth, and it would appear that most of these animals increase in size during the whole of their lives. The manner

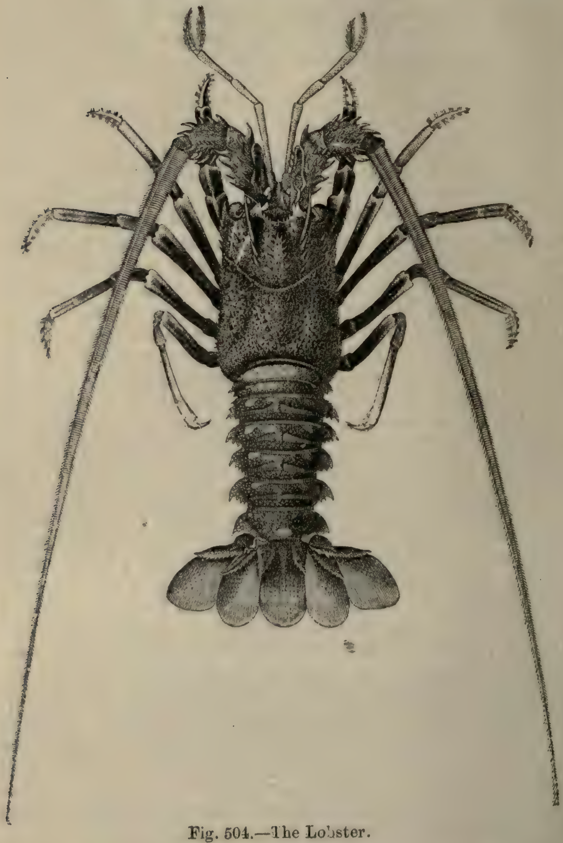

Fig. 504.—The Lobster.

in which they throw off their old covering is very singular; in general they contrive to leave it without causing the slightest deformation, and when they quit it the whole surface of their body is already covered with a new sheath ; but this is still soft, and only acquires its necessary solidity at the end of some days.

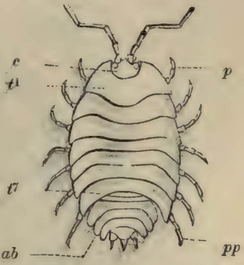

Fig. 505.—Cloportes (Oniscus), Wood Louse.

The bodies of crustacea are composed of a series of rings more or less distinct. Sometimes the most of these segments are simply articulated with each other, and have a tolerably wide range of mobility. Sometimes they are all united together, and can be distinguished only by grooves at the points of junction. Finally, at other times, their union is still more complete, and it is only by analogy that the zoologist is induced to consider the segment resulting from their fusion as composed of several rings rather than one. There results, as might be expected, very wide differences in the general form of these animals; and if we compare together a cloportes (Fig. 505) or wood louse, a talitrus (Fig. 169),[*] and a crab (Fig. 506), for example, one might be led at first sight to believe them to be constructed on wholly different types; but a deeper study of their structure shows that the composition of their tegumentary skeleton is essentially the same, and that the differences depend on this, that the greater number of the rings, completely distinct and moveable in the oniscus, are united to each other in the crabs, and that certain analogous parts do not present in these two genera the same proportions. Thus, in the oniscus (Fig. 505) or in the talitrus (Fig. 169) we find a distinct head (*c*), followed by a thorax composed of seven rings, resembling each other (t^1, t^7), and carrying each a pair of limbs (*p*, *pp*); finally, at the posterior part of the body we find an abdomen (*ab*), formed also of seven segments, whose size diminishes rapidly, but whose form is nearly the same as in the thorax. In a crab, on the contrary (Fig. 506), the head is not distinct from the thorax, and forms with all this section of the body a single segment covered with a large solid buckler, named shell, or *carapace ;* finally, the abdomen at first escapes the sight, because it is folded under the thorax, and is but small. Nevertheless, it is easy to demonstrate that in the crab, as in the oniscus, there exist behind the head seven easily recognisable thoracic rings, and that the carapace is not a new organ created for the former, but merely the dorsal portion of one of the rings of the head which has acquired an extreme development, and encroached on the neighbouring rings, In other animals of the same class, the general form of the body is removed still further from those of which we have just spoken. Thus the limnadiæ are enclosed between two oval bucklers, united together after the manner of the valves of the oyster; and it is after having removed this moveable cuirass, that the true annulated structure of their bodies is observed (Fig. 519);

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[*] Oniscus locustra; talitrus: Lat. Of the genus Gammarina; family Gammarus; sand-hopper.—R. K.

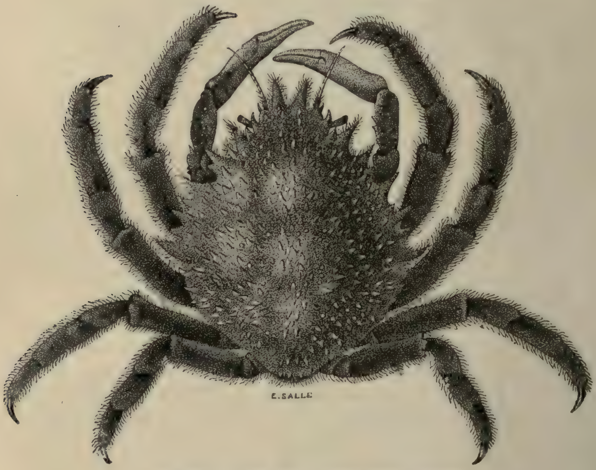

Fig. 506.—The Crab (Maïa); Sea Spider.

the cypris, abounding in stagnant waters, presents an analogous disposition, only the rings of which their bodies are composed are still more difficult to be recognised. Finally, we may cite the lernæa, which at the adult age presents the strangest forms (Fig. 155, 156), but which when young has a distinctly annulated structure (§ 366). This comparative study of the tegumentary skeleton of the crustacea presents a great interest, in respect of physiological anatomy, of which one of the most important branches is to investigate the modifications which nature causes the same organic elements to undergo, to adapt them to various uses, and to create with analogous or homologous materials dissimilar instruments; but the limits we have assigned to these lectures do not admit of our touching at greater length on this subject.

[The question here mooted by my friend M. Milne Edwards embraces nearly the whole question of the transcendental anatomy, the only view in which anatomy and zoology become a science. The following observations, reprinted from my work on the *Races of Men*, will sufficiently explain this to the reader:—*

"By dissection the dead are analysed or reduced to certain assemblages of organs, holding relations, often mechanical, to each other. They all perform certain functions, some of which have been imperfectly guessed at; made out in a coarse way: organs of locomotion exist—bones, ligaments, joints, muscles, or flesh; organs of sensation, and thought, and will; the brain and spinal marrow; the nerves; organs of digestion and assimilation, the stomach and digestive tube, and their appendages; lastly, organs of breathing, essential to life; the lungs, by which we draw from the air the breath of life. Bloodvessels acted on by a heart carry the blood through the frame. Out of this vital fluid the body is constructed, repaired, and formed. Now if we select any one of these organs, or sets of organs, we shall find that, in one shape or another, it extends through the whole range of vertebrate animals, most probably through the entire range of animal life, but under a shape or form no longer recognisable by our senses. A few instances will suffice to explain this. There is no occasion for any minute or technical exposition of facts, which are, as it were, on the surface. Let us first turn our attention to the skeleton. Not that this assemblage of levers proves better than any other set of organs the unity of structure, the unity of organization sought to be superadded by the German and Sclavonian philosophy, to the unity of plan laid down by Newton; I do not even think so well; but it presents materials easier to be handled, easier to be inspected, obtained, and understood.

"The basis of the skeleton, whether mere animal or man, is a series of bones jointed or articulated with each other. In common language it is called the back bone. You see how violently inaccurate such a term is, when applied to a series of bones perfectly distinct from each other, possessing most of them a distinct mobility. These bones we call *vertebræ;* here is one of them. When studied by the surgeon or medical man, it is viewed by him merely as a portion of the skeleton: to the philosophic anatomist it becomes the type of all vertebrate animals, of the entire skeleton, limbs and head included; of the organic world, vertebrate and invertebrate. Carried further, it possesses the form of the primitive cell; of the sphere; of the universe.

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* See the *Races of Men; a Fragment.* By R. Knox. Henry Renshaw, London. This work was originally delivered in the form of Lectures.—R. K.

"Now look at this bone in man—it appears simple, but it is not so. Originally, that is, in the young, composed of many distinct portions, which afterwards unite with each other, but which remaining distinct in many animals, as in fishes, proves to us, that throughout the whole range of animals so formed, the vertebræ do not really differ so much from each other as might at first appear: that, in fact, the elements forming them seem the same almost numerically, giving rise to the well-grounded belief, that, in the embryo, the elements of the skeleton may be, after all, the same in every animal. From man to the whale, all is alike; one theory explains all; one idea or plan pervades all.

"Let us trace this chain of bones upwards and downwards; see how downwards (coccygeal vertebræ) certain elements cease to be developed, or do not grow: still the plan is the same; identical; analogous, as regards the individual, that is, repeated; homologous or identical, as regards one animal compared with another. Look to this section of the skeleton, called the head; the bones seem widely different from the vertebræ; but it is not so. They are merely vertebræ, repeated, upon a larger scale as may be required: a chain of vertebræ form, then, the head or cranium. These great truths we owe exclusively to the illustrious South German and Sclavonian schools of transcendental anatomy; to Oken and Spix, Autenrieth, Frank, Goethe, and a host of others. * * *

"A vertebra must have a type; that is, a plan sufficiently comprehensive to include all forms of vertebræ. Now where is this to be found? Is it an ideal type not yet discovered? Or is it to be found in any extinct or living animal? I apprehend that it may or it may not have been found, but this in no way interferes with the principle that there must be a type laid down by nature; eternal; equal to all manifestations of form, extinct or living, or to come.

"But the discovery of such a type could only be made were the anatomy of all animals that ever lived known to us; perhaps not even then, for the future must be wrapt up in the past: and what seems to us now a mere speck of bone, a nucleus, a point unimportant, nay, scarcely discernible, may, in a future order of things, become an all-important element. As thus:—

"If birds did not exist, we could scarcely conceive the high organization to which the third eyelid, in man a mere rudiment, attains in them. Not wanted in man, the organ sinks to its rudimentary and scarcely perceptible condition. Of essential service in birds, it suddenly acquires its seemingly highest development. Yet the organ was always present, rudimentary in one, developed in the other. Let us take another instance.

"The adult, or grown-up man, has, as you all no doubt know, three bones to each toe, with the exception of the first; these three bones are connected to each other, and to the metatarsal bone, their supporters, by three joints. In the feet of birds you meet with four or five bones in certain of the toes; and it might seem to you that the feet of birds were formed on a different numerical plan at least; but it is not so: for in man, as in birds, each digital bone is formed of two elements, or distinct bones, at first, that is, in the young of each: as the bird grows up, they remain distinct—in man, on the contrary, they unite—that is all. The arrangement is not only analogous, but homologous or identical, in the strictest sense of the terms.

"Again, remember that a thousand similar instances might be given: I merely select a few of the easiest understood.

"In man there is a little cartilage, scarcely perceptible, connected to one of those bones occupying the nostrils, called turbinated bones. It may or it may not in him serve any purpose; that is a matter of pure indifference. It is a rudimentary and a useless organ seemingly. Now, mark the extension and development of this cartilage or organ in the horse—still more in the whale; in the horse, where it most admirably serves to shut off the great cavities of the nostrils from the vestibular cavities in front—thus protecting them from foreign bodies: in the whale, acquiring their presumed highest development, these cartilages, now grown to the size of bolsters, return after breathing, into the vast nostrils of the whale from which they had been momentarily withdrawn, filling them up, sealing them hermetically against the pressure of a thousand fathoms deep of water, which they sustain with ease, when, plunging into the vast abyss of the ocean, the giant of nature seeks to avoid his enemies.

"Let us now briefly review the progress we have made in this the highest of all analyses: deepest of all theories: most important to man. Man, we have seen, stands not alone, he is one of many; a part and parcel of the organic world, from all eternity. That organic world is the product of secondary causes. During his growth he undergoes numerous metamorphoses, too numerous even for the human imagination. These have a relation to the organic world. They embrace the entire range of organic life, from the beginning to the end of time. Nature can have no double systems; no amendments or second thoughts; no exceptional laws. Eternal and unchanging, the orbs move in their spheres precisely as they did millions of years ago. Proceeding, as it were, from an invisible point endowed with life, he passes, rapidly at first, through many forms, all resembling, more or less, either different races of men from his own, or animals lower in the scale of being; or beings which do not now exist, though they probably *once* did, or may at some future time. When his development is imperfect, it represents then some form, resembling the inferior races of men, or animals still lower in the scale of being. Moreover, what is irregular in him is the regular structure in some other class of animals. Take, for example, the webbed hand or foot occasionally found in man, constant in certain animals—as in the otter and beaver; constant also in the human fœtus, that is, the child before birth. Take, for example, the cuticular fold at the inner angle of the eye, so common with the Esquimaux and Bosjesman or Hottentot (the corresponding yellow races of the northern and southern hemispheres), so rare in the European, but existing in every fœtus of every race. Nor let it be forgotten that forms exist in the human fœtus which have nothing human in them in the strictest sense of the term; that the fœtus of the Negro does not, as has been stated, resemble the fœtus of the European, but that the latter resembles the former, all the more resembling the nearer they are to the embryonic condition. Unity of structure, unity of organization, unity of life, at the commencement of time, whether measured by the organic world or by the duration of individual life." This is the law.

The relation of species to genus also merits our deepest attention.*

"My first observations were made on animals low in the scale of the vertebrata,—on fishes, in fact. I selected, as I shall presently more fully explain, the natural family of the Salmonidæ, as the one to which I had given most attention. In the young of the true salmon I found the specific characters of all the subfamilies of the genus present; that is, red spots, dark spots of several kinds, silvery scales, proportions, and a dentition identical. The young fish before me was, in fact, a generic animal, including within it the specific characters of all the species composing the natural family. To connect this generic animal with any species, you have but to imagine the disappearance of certain characters then and there present. Nothing requires to be added. Take, for example, the dentition—the *dentition of the vomer*, to which M. Valenciennes attaches so much importance, and in which he has endeavoured to discover the true distinguishing characters of the three sub-families into which that distinguished naturalist subdivides the Salmonidæ. Look at these vomerine teeth in the young of any of the species—that is, as I view it, in the *generic animal,* and in the adult of all the species, that is, in the animal *specialized*—and we shall find that the *generic animal* possesses a dentition embracing all the characters by which the fully-developed individuals are afterwards to be recognised. But it is the young alone which comprises all, combines with the anterior group of teeth (teeth of the chevron) a double row on the body of the vomer, which row, becoming in due time single, characterizes, according to M. Valenciennes, the adult of the sub-family Forelle, or, disappearing altogether, marks the true salmon when adult, the common trout growing up with the dentition of the generic animal. The primitive type, then, is not lost, as M. Valenciennes seems to have supposed, but is retained in one species at least of the natural family. As with the dentition, so with the colorations and proportions: and thus the law of generation being *generic,* and not *specific,* marks the extent of the natural family, its unity in time and space, the fixity of its species, the destruction of some and the appearance of others being but the history, not of successive creations, but of one development, extending through millions of years, countless as the stars of the firmament.

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* See "Memoirs on the Philosophy of Zoology," in *The Zoologist*. J. Van Voorst, London; and in the *Lancet*, 1855.—R. K.

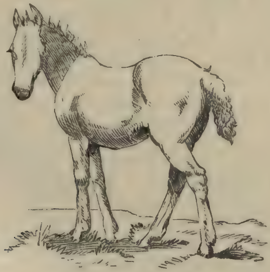

Fig. 506*a*.—The Colt.

"Look now at the colt a few months old as it gambols through the fields, and say, does it resemble the domestic animal from which it is sprung, in colour, proportions, movements, attitudes? Not in the least. Its colour is a rich deep fawn, to be found only amongst the *wilde;* in its proportions it resembles the quagga or zebra, and as it canters along, its rocking-horse motion and short frisking tail recal to the mind scenes only to be seen in Southern Africa, on the plains of the Koonap or the slopes of the Winterbergen, where roams the wild horse, to which this young of a domestic horse bears the strongest resemblance. The obvious inference is, that even in animals so high in the scale of mammals as the solidungula, the young is a *generic animal*, including in it the colour, proportions, movements, and habits of the genus, or natural family, of all its species, wherever placed, and representing, more especially in this instance, a wild species of that family, never domesticated nor subdued by man. Even here, where we should expect *specific* and other influences to have told strongly on the product—that is, the young, we find the *generic* law to be in full force, and that the young of the domestic horse resembles a species peculiar to another region of the earth. The natural family, then, of the solidungula embraces in the young of each species all the forms which it, the genus, can or has assumed on the earth. The quagga and the zebra may become extinct; but their forms remain in the generic young of whatever species still lives. The fossil horse belonged, no doubt, to the same family; as the exterior is lost, the precise species cannot now be determined. That he belonged to any species now living I do not believe; but he was of the family, and may appear again. Thus the successive appearance of new forms or species is no new creation, but merely the development of forms already existing in every natural family. The extinction of species which has gone on through millions of years has led some to the belief that nature hastens onwards to the extinction of life on the globe. It is possible; but I lean to the opposite opinion, believing that living nature will have no end. That which has been may be again, the potentiality existing in every species of every natural family; and to this creed point the infinite affiliations of germs, not confined to natural families, but extending to all that lives. These are speculations on which I do not enter. Primordial forms are visible in all germs; the germs themselves must be eternal.

"If we inquire into the law of generic forms lower in the scale, as in fishes, to which I have just alluded, we find still stronger confirmation of the point I now seek to determine. The natural family of the Salmonidæ, as the one with which I am best acquainted, was that fixed on for the inquiry. Look at the young salmon when but a few inches in length, and you will find that in its dentition, colouring, and proportions, it is not a *specific* but a *generic* animal—*i.e.* it possesses (and is therefore perfect) all the natural history characteristics of the three sub-families into which the Salmonidæ have been divided. At first, for example, its dentition is the type of the common trout; as it grows it assumes the character which we find to prevail in some of the Forellé, or sea trout. Lastly, it assumes the true salmon dentition; but that which especially merits attention is, that the original type of the generic being is of a character so ample as to embrace all possible forms which the dentition can assume in any species of that natural family. Nothing is wanting; nothing new appears; nothing has to be supplied; all is foreseen; all provided for. To institute a species, all that is required is to omit, or cause to disappear, or cease to grow, some parts of the organ or apparatus already existing in the generic being. In every natural family there is a species which bears, to the generic animal, that is, to the young, a stronger resemblance than any other. In the Salmonidæ it is the common trout of fresh-water rivers, but there may be others. In the Solipeda it seems to be the quagga of Southern Africa."—R. K.]

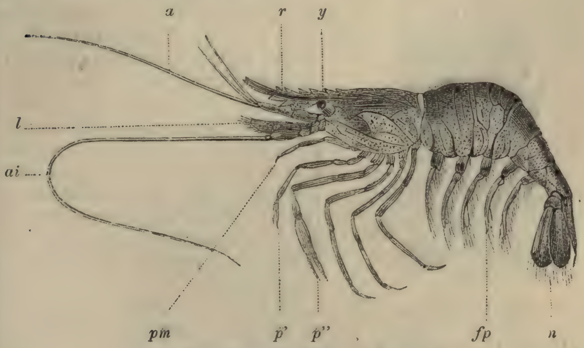

Fig. 507.—Palæmon (Fab.); Prawn.*

§ 563. The lateral appendages of the various rings constituting the body are in general very numerous, and present also considerable differences in their conformation and their uses, whether we consider them in the various parts of the same individual, or compare them in distinct species. Those of the first rings, in general, have relations to the functions of animal life, and carry eyes or form antennæ; the following surround the mouth, and serve for the prehension or the division of the food (*g*, 143, 144); those of the middle portion of the body constitute limbs for locomotion, and those placed still further back have very variable uses, but serve in general for respiration or reproduction: finally, this long series terminates generally by one or more pairs of limbs, arranged to serve as fins.

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* *a*, antennæ of the first pair; *ai*, antennæ of the second pair, or inferior antennæ; *l*, lamellated appendix covering the base; *r*, rostrum, or frontal prolongation of the carapace; *y*, eyes; *pm*, external limb-jaw: *p'*, thoracic limb of the first pair; *p''*, thoracic limb of the second pair; *fp*, false swimming limbs of the abdomen; *n*, caudal fin.

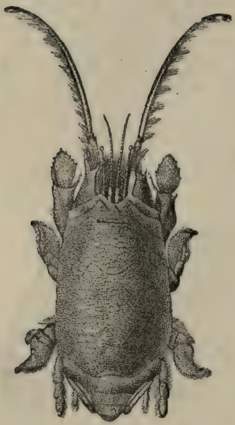

Fig. 508.—Hippa.

The head, or rather the cephalic portion of the body, carries the eyes, the antennæ, and the buccal appendages: sometimes it is divided into several distinct rings, as in the squilli or shrimps, for example (Fig. 515): although generally it presents no such separation, being formed only of a single segment, which seems to represent seven rings, confounded together. Sometimes it is moveable, and distinct from the thorax (Fig. 505); at other times, on the contrary, it is united to this second portion of the body, which in its turn is composed in certain species of rings articulated together, but distinct; in others, united into a single mass.

The antennæ are almost always composed of two pairs, and constitute in general very elongated filiform horns, or what at least resembles them. The limbs are connected in pairs with the different thoracic rings; there are frequently seven pairs: in the cloportes (Fig. 505), the prawns of rivulets, and the talitri, or sand-hoppers, for example; but at other times, as may be seen in the crabs (Fig. 506) and the craw-fish and lobsters (Fig. 143), their number is reduced to five pairs only; for the appendages, which in the first case formed the four anterior limbs, are then turned to other uses, and transformed into organs of mastication. There exist also very great differences in their structure; in some crustacea they are wholly foliaceous, membranous, and exclusively adapted for swimming (Fig. 518); in others they have the form of small flexed (like elbows) columns, articulated, and disposed only for walking; in others still, besides remaining adapted for this kind of locomotion, they become suited to act as so many small spades wherewith to dig the earth, and in that case they are enlarged and lamellated towards the extremity (Fig. 508); and still, finally, in others, they terminate in forceps, and become instruments of prehension, fulfilling at the same time their ordinary functions of instruments of locomotion (Fig. 143). In the swimming crustacea, such as the craw-fish and the lobster (Fig. 504), the palæmon (Fig. 507), &c., the abdomen presents in general a considerable development, and terminates by a large fin, so as to become the principal organ of locomotion; but in those intended to walk more than they swim, it is in general very small, and folded under the thorax: in the crabs, for example, this portion of the body is reduced almost to nothing, and constitutes then a moveable apron placed on the lower surface of the body between the limbs.

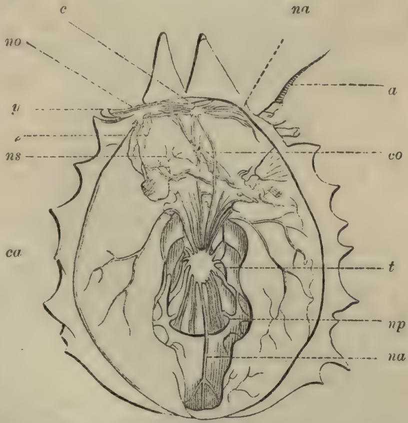

Fig. 509.—Nervous System of a Crab: the Maïa; Sea Spider.*

§ 564. The nervous system is composed of a double series of ganglions, situated on the ventral aspect of the body near the median line. Their number corresponds in general to

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* Carapace, laid open:—*a*, exterior antennæ; *y*, eyes; *e*, stomach; *c*, brain; *no*, optic nerves; *co*, œsophagal collar; *ns*, stomato-gastric nerves; *t*, thoracic ganglionary mass; *np*, nerves of the limbs; *na*, abdominal nerve.

that of the distinct segments of which the body is composed, and those of the first pair are always lodged in the head or in front of the gullet, where they constitute a sort of brain (Fig. 509, *c*): but the arrangement of the ganglions of the thorax and abdomen varies much; sometimes they are at equal distances from each other, and form, with their cords of communication, a chain extending from one extremity of the body to the other; sometimes they approach each other more or less, and sometimes they are altogether reunited into a mass situated towards the middle of the thorax (Fig. 509, *t*). It ought also to be observed, that the centralization of the nervous system becomes more and more complete in proportion as the animal rises in the scale of being or acquires a more elevated organization. Moreover, all the crustacea have very limited faculties, and none amongst them present much interest in respect of their habits. The eyes are formed pretty nearly as in insects. Sometimes they are simple; but generally they are compound or composite, and in all the more perfect crustacea they are carried on moveable peduncles (Fig. 510), an arrangement not found in any of the other divisions of this great class of articulated animals.

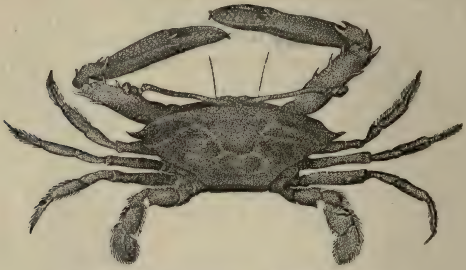

Fig. 510.—Podophthalmus; Stalk-eyed Crab.

In many crustacea there exists also an organ of hearing, situated at the base of the external antennæ (Fig. 511), composed of a small membrane resembling a *membrana tympani*, above which is found a kind of vestibule filled with liquid, and enclosing the termination of a special nerve. Nothing is for certain known respecting the faculties of smell and taste in these animals.

§ 565. Most crustacea live on animal substances; but they offer great differences in their *régime;* some live only on liquid matters, others on solid food, and differences are observable in the construction of the mouth, corresponding to their varied circumstances. In the masticating crustacea there is before the mouth a short transverse lip, followed by a pair of mandibles, a lower lip, one or two pairs of jaws properly so called, and in general one or three pairs of auxiliaries or limb-jaws, serving chiefly for the prehension of the food (Fig. 144). In the crustacea which live by suction, we find, on the contrary, the mouth prolonged into a kind of beak or proboscis, resembling those insects whose habits are analogous. In the interior of this tube are slender pointed appendages, performing the functions of small lancets, and on either side we find generally organs analogous to the auxiliary jaws of the grinding crustacea, but which are formed to enable the animal to fix on its prey.

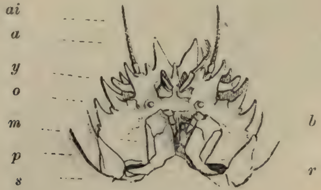

Fig. 511.*

§ 566. The digestive canal extends from the head to the posterior extremity of the abdomen, and is composed of a very short gullet, a large stomach (*e*, Fig. 513), armed in general internally with powerful teeth, a slender intestine, and a rectum. In some crustacea, the bile is secreted by biliary vessels sufficiently resembling those of insects; but in general there exists a very voluminous liver (*fo*), divided into several lobes, and composed of a number of small tubes, terminating in a *cul de sac*, and grouped around a ramified excretory canal, the extremity of which terminates on each side in the intestine near the pylorus.

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* Anterior portion of the inner surface of the body of a Crab (Maïa) Sea Spider:—*ai*, internal antennæ; *a*, external antennæ: *y*, eyes; *o*, auditory organ; *m*, limb-jaws; *b*, mouth; *p*, base of the anterior limbs; *i*, entrance to the respiratory cavity; *s*, sternum.

§ 567. Nothing is known of the manner in which the chyle passes from the intestine into the circulatory apparatus. The blood is colourless, or slightly bluish or lilac, and coagulates readily. This liquid is set in motion by a heart placed on the median line of the back (*c*, Fig. 427), and composed of a single cavity. Its form varies, and its contractions drive the blood into the arteries, by which it is distributed to all parts of the body. The veins are replaced by the lacunæ which the various organs leave between them, and which are lined by a thin layer of cellular tissue; they terminate in vast sinuses, situated near the base of the limbs (*s*, Fig. 512), and from these cavities the blood proceeds to the respiratory organs, then returns to the heart by distinct canals named branchio-cardiac (*c b*, Fig. 512).

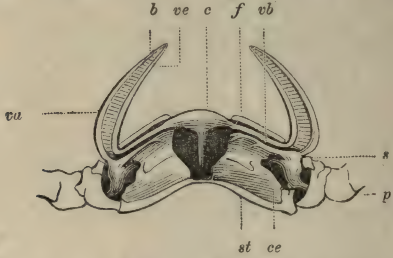

Fig. 512.—Circulatory Apparatus of a Crab.*

§ 568. The crustacea are almost all essentially aquatic animals: thus their respiration takes place almost always by means of branchiæ, and when these organs are wanting, it is the skin of certain parts of the body (most generally of the limbs) which takes their place. Thus in the crabs, lobsters, and all crustacea of analogous organization, the branchiæ consist of a considerable number of small cylinders, disposed like the bristles of a brush, or of small lamellæ, piled on each other like the leaves of a book. These organs are fixed by their extremity to the inferior margin of the arch of the flancs (Figs. 512 and 514), and are enclosed in

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* Vertical section of the thorax of a crustaceous animal, showing the course followed by the blood; *c*, the heart; *s*, venous sinuses; *b*, branchiæ; *va*, vessel carrying the venous blood to the branchiæ; *ve*, vessel receiving the blood after its passage through the capillary network of the branchiæ; *vb*, branchio-cardiac vessels; *f*, arch of the flancs: *st*, sternum; *ce*, cellule of the flancs; *p*, base of the limbs.

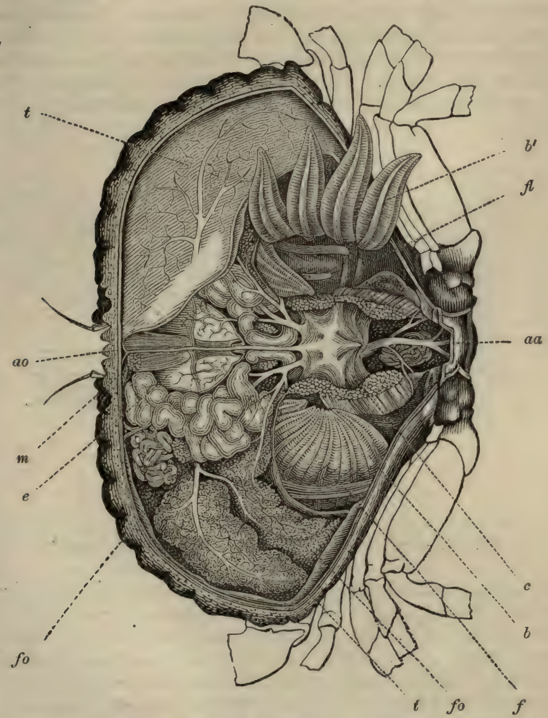

Fig. 513.—Anatomy of the Crab (Tourteau); Common edible Crab.*

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* The greater part of the carapace has been removed :—*t*, portion of the cutaneous membrane lining the carapace; *c*, the heart; *ao*, ophthalmic artery; *aa*, abdominal artery; *b*, branchiæ in their natural position; *b′*, branchiæ, reversed externally, to show their afferent vessels; *fl*, arch of the flancs; *f*, flabelliform appendix, or *epignathus* of the limb-jaws; *e*, stomach; *m*, muscles of the stomach; *fo*, the liver.

two large cavities situated on the sides of the thorax, and comprised between the carapace and the arch of which we have just spoken, an arrangement which does not occur in any other animal of this class. The respiratory cavity communicates externally by two openings; the one serving for the entrance of the water, almost always situated between the base of the limbs and the edge of the carapace (*r*, Fig. 511), the other, destined for the escape of this liquid, is placed at the sides of the mouth. Finally, the renewal of the water on the surface of the branchiæ is caused by the movements of a large valvule situated near this latter opening, and formed by a lamellated appendix of the jaws of the second pair (*c*, Fig. 144; *i*, Fig. 514). In other crustacea, the squillæ (shrimps) for example (Fig. 515), the branchiæ have the form of bunches of feathers, and in place of being enclosed within the thorax, float freely, externally, and are attached to the abdominal limbs; in others still, as in the prawns of rivulets and the talitri, they are formed of membranous vesicles fixed to

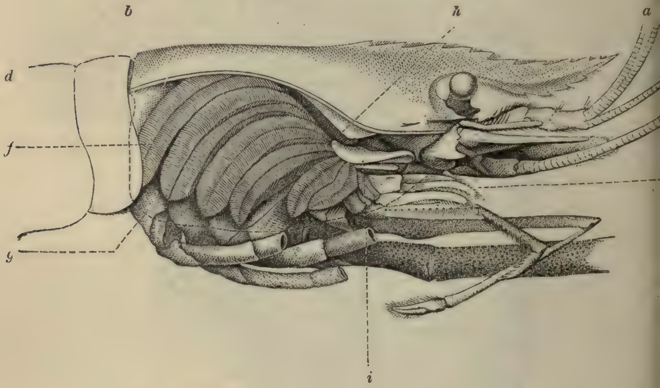

Fig. 514.—Respiratory Apparatus of a Palæmon, or Prawn.*

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* *a*, rostrum; *b*, carapace; *c*, base of the antennæ; *d*, base of the abdomen; *e*, base of the limbs; *f*, branchiæ; *g*, dotted line, pointing out the inferior edge of that portion of the carapace which covers the branchiæ, and which has been removed in this preparation; *h*, efferent canal of the respiration; *i*, valvule; *j*, extremity of the efferent, or expiratory canal.

the base of the limbs, under the thorax; and these perform the functions of branchiæ. Finally, in the crustacea isopoda, respiration is accomplished by means of false abdominal limbs, which are foliaceous and membranous.

§ 569. There exists a very small number of these animals which live in air; but they form an exception to what we have already said relative to the differences of structure of the respiratory apparatus in aquatic and terrestrial animals: for in place of being furnished with lungs or tracheæ, they breathe by branchiæ, like the first; only these organs are disposed in such a way as to maintain themselves in a moist state required for the exercise of their functions. The gecarcini or land crabs (Fig. 516), met with in various regions of the globe, but abounding especially in the Antilles, where they are known by the name of *tourlourous*, present a remarkable example of this anomaly. In place of living in water as the ordinary crustacea, they are terrestrial, and although they have gills, some of them become asphyxiated rapidly by submersion. Their respiration is, in fact, too active for the small quantity of oxygen dissolved in water sufficing for their wants; whilst in the air, they of course find this material in abundance; and a disposition analogous to that which we have already met with in fishes (Fig. 393), permits them to remain out of the water without their branchiæ drying up so as to become unfit for the performance of their

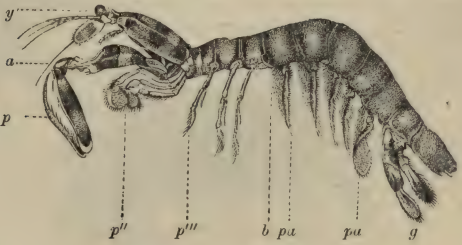

Fig. 515.—Squilla (Shrimp).*

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* y, eyes; a, antennæ; p', limbs of the first pair; p'', limbs of the three following pairs; p''', thoracic limbs of the three last pairs; pa, false abdominal limbs; b, branchiæ; g, caudal fin.

functions. Sometimes there exists at the bottom of the respiratory cavity a sort of trough, destined to act as a reservoir for the water required to maintain their branchiæ in a moist state; at other times, we find on the arch of this cavity a spongy membrane, which seems to serve the same purpose. Most of these land crabs live in moist woods, concealing themselves in holes which they dig in the soil, but the localities they prefer vary according to the species; some live in low marshy grounds near the sea; others prefer wooded hills far from the seashore, and at certain epochs these last quit their usual place of abode to reach the sea.*

The *cloportes* (Fig. 505) are also terrestrial crustacea, whose aërial respiration is accomplished by means of foliaceous laminæ situated under the abdomen, and which, in other animals formed in the same way, perform the functions of branchiæ.

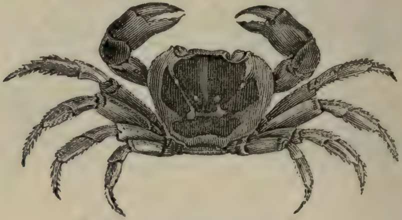

Fig. 516.—Gecarcius, or Land Crab.

§ 570. The crustacea are all oviparous, and the sexes almost always distinct; but some are hermaphrodite. The female may in general be distinguished from the male by the greater size of the abdomen, and after having laid her eggs, she carries them during a certain time suspended under that part of the body, or even enclosed in a sort of pouch formed of appendages belonging to the limbs; sometimes the young are produced in this pouch, and remain there until they have passed through their first moulting. The young in general do not undergo true metamorphoses. Sometimes, however, they acquire by the progress of age a greater number of limbs, and there are some which completely change their form during the early periods of life; the lernææ offer us an example of this transformation (Fig. 155).

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* Such are the circumstances which render difficult all minute application of the laws regulating the structure and functions of the now existing living world to the remains we find in past geological epochs. That which seems aquatic may have been terrestrial, and *vice versâ*. Not that anatomy is at all doubtful when fully known, but the soft structure being destroyed, we want a valuable element in the inquiry.—R. K.

§ 571. The class crustacea, amongst which we must arrange the cirrhipeda, placed by many naturalists, but erroneously, amongst the mollusca, is divided into five principal groups, namely,—

The podophthalmaria, which have the eyes carried on moveable peduncles, the anterior portion of the body furnished with a carapace, ambulatory limbs, the mouth armed with jaws disposed for mastication, and the organs of respiration formed of branchiæ properly so called.

The edriophthalmia, whose eyes are not pedunculated, the thorax exposed, the ambulatory limbs, the masticatory buccal apparatus and the branchiæ replaced by a portion of the series of the limbs.

The branchiopoda, in which the limbs are all foliaceous, and perform at the same time the functions of fins and branchiæ.

The entomostraca, in which the limbs are natatory but not branchial, and in which the mouth is usually organized for suction. Finally, the Xiphosuri, in whom the mouth has no appendages which especially belong to it, but is surrounded with limbs, the base of which performs the functions of jaws.

[When I first made the discovery that the vendace, the herring, and many fine species of the salmonidæ, live almost exclusively on various kinds of the entomostraca, the view was violently contested by naturalists; and although the facts submitted to them admitted of no sort of doubt, to this day I have not overcome their prejudices. The history of my inquiry was afterwards taken up by my former student and assistant, Mr. Henry Goodsir; and his remarks, as those of an honest and careful observer, may be found agreeable to the reader, more especially as this most amiable and talented young man perished in his youth. He was one of the companions of Sir John Franklin in his last expedition.

"Hearing our fishermen often speak of 'something' which abounded in great quantities in the Firth of Forth during the summer months, which they called *Maidre*, and of which they never could give me a clear description, I determined to examine it for myself.

"It was stated to me that this *maidre* was generally found in greatest quantity round the Island of May, *only* during the summer months, and especially during the time of the herring-fishing.

"I find, however, that *maidre* must abound during the spring months also, as the stomachs of the herrings caught at present are in most cases filled with it.

"In frequent excursions to the Isle of May, during last year, I found that the *maidre* consisted of one immense continuous body of minute animals.

"The animals composing this immense body were those belonging to the cirrhipeds, crustaceans, and acalepha.

"Of these the crustaceans existed in the greatest numbers, or rather *masses*, for it gives a faint idea to speak of numbers. The crustacea were amphipoda and entomostraca, the former of which were very abundant, but the latter (entomostraca) formed the greatest proportion of this innumerable body of animals.

"The acalepha also abounded, of which the different species of beroœ were seen in greatest numbers.

"I remarked that the masses of *maidre* abounded most at the sheltered sides of the island. On looking into the water, it was found to be quite obscured by the moving masses of entomostraca, which rendered it impossible to see anything, even a few inches below the surface.

"But if by chance a clear spot is obtained, so as to allow the observer to get a view of the bottom, immense shoals of coal-fish are seen swimming lazily about, and devouring their minute prey in great quantities. Occasionally small shoals of herrings are seen pursuing them with greater agility. It is in the deep caverns, however, in the sides of the island, where the *maidre* is found in greatest abundance; and accordingly, we find that all those animals pursuing them are found there in greater abundance also.

"The fishermen, during the earlier periods of the fishery, take advantage of this, and, shooting their nets across the mouths of the caves, alarm the herrings in them, either by throwing large stones from their boats or from the tops of the rocks, and in this way sometimes succeed in taking great shots.

"These, however, are not the only animals which prey on the immense bodies of *maidre*.

"Great numbers of cetacea often frequent the neighbourhood of the island at this time; droves of dolphins and porpoises, swimming about with great activity; and occasionally an immense rorqual may be seen raising his enormous back at intervals from the water, and is to be observed coursing round and round the island.

"I have examined great numbers of these cetaceous animals (dolphins and porpoises) within the last few years, and never have seen anything resembling the remains of herrings, or fish of any other kind, in the stomach, although the former fish was very abundant at the same time in the Firth. I make no doubt, therefore, that the cetacea only accompany the herring in pursuit of their common food, viz., entomostraca and acalepha.'

"I have already stated that it was entomostracous animals which formed the great mass of the *maidre*. Among these I obtained a great number of nondescript species, one of which I shall now describe.

"On one of my occasional visits to the Isle of May, I observed that at a considerable distance from the island the sea had a slightly red colour, that this became deeper and deeper as we neared the island; and also that the surface of the water presented a very curious appearance, as if a quantity of fine sand were constantly falling on it. I thought at first that this last circumstance proceeded from rain, but presently I found that both phenomena were caused by a great number of small red entomostraca, which I had never before observed in such abundance. On further observation, I found that it belonged to the genus Cetochilus of M. Rousel de Vauzeme, who has given a detailed description of his species (C. Australis), the only one hitherto known, in the first vol. of the *Annales des Sciences Naturelles*. This author states that it is found in the Pacific Ocean, and in the middle of the Atlantic Ocean, about 40° south latitude. It forms, he says, very extensive banks, which impart a red colour to the water, and which furnish a plentiful supply of food to the whales frequenting those seas."—R. K.]

§ 572. The division of podophthalmaria comprises the greater number of crustacea, and is composed of all those whose organization is the most complex and the most perfect. It is subdivided into two orders, the *decapoda* and the *stomapoda*.

§ 573. The order of the decapoda comprises the crabs, lobsters, and all the other crustacea in whom the branchiæ are internal, and in whom the limbs are five pairs in number. The head and the thorax of these animals are confounded into a mass covered by a large carapace or case (Fig. 517); this dorsal buckler advances in general more or less in front, descends on each side to the base of the limbs, and backwards as far as the origin of the abdomen (Figs. 504, 507). It results from this arrangement that we can no longer recognise throughout all this part of the body any trace of an annular division; but beneath, most of the rings, although united together, are still recognisable, and leave at their points of junction the lines of suture, more or less distinct. The eyes are always carried on the extremities of a pair of moveable appendages which spring from the first segment of the head; sometimes the length of their peduncle is very considerable (Fig. 510), and in general they may be folded or withdrawn into the cavities performing the office of orbits, and which are formed by the anterior margin of the carapace, shell, or case. The organs of locomotion are also very well developed in these crustacea; several can run with extreme rapidity, others swim still more swiftly. Their limbs, as we have already said, are five pairs in number, fixed to the five last rings of the thorax; but in general those of the four last pairs alone serve for locomotion, and those of the first pair terminating in a forceps more or less perfect, become instruments of prehension (Fig. 517). In the decapoda the best adapted for swimming (such as the cray-fish, the lobster, and the palæmons), the body is elongated, and the abdomen terminated by a large transverse fin (Fig. 504); whilst in those which are formed for running, the crabs, for example, the abdomen is very short, has no terminal fin, and is curved under the thorax.

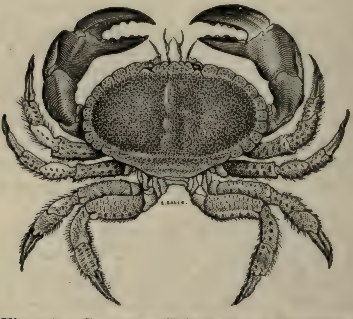

Fig. 517.—Common edible Crab; C. Pagurus.

§ 574. The stomapoda have also the eyes carried on moveable peduncles, the thorax covered entirely or partly by a carapace, and the limbs cylindrical; but their branchiæ are not enclosed in the cavities of the thorax, but float under the abdomen, or are altogether wanting. The squilla (Fig. 515), of which we have already spoken, belongs to this order.

§ 575. In the division edriophthalmia, the head is distinct from the thorax, and this last part of the body is composed of a series of seven rings, each carrying a pair of limbs. Thus, as we have already said, there is not any carapace, the eyes are not pedunculated, there are no branchiæ properly so called, but the respiration is performed by means of various appendages borrowed from the locomotory apparatus. Naturalists arrange under this group,

1. The amphipoda, which have the abdomen well developed, and carry under the thorax a double series of respiratory vesicles, formed by the internal branchiæ of the limbs. The prawns of rivulets and the talitri (Fig. 169) offer us these characters.

2. The lœmodipoda, which resemble the preceding in the disposition of the organs of respiration, but which have only a rudimentary abdomen.

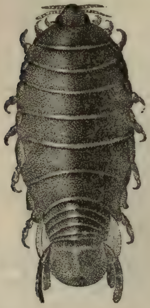

Fig. 518.—Anilocra.

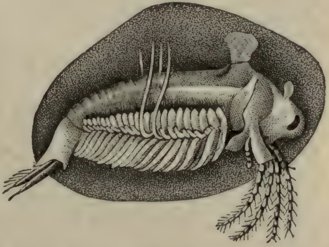

Fig. 519.—Limnadia.*

3. The isopoda, in whom the abdomen is, on the contrary, well developed, and carries beneath a series of false branchial limbs. The anilocra (Fig. 518), the sphæroma, and the class woodlouse, cloportus (oniscus) belong to this order.

§ 576. The branchiopoda, as we have already said, are small crustacea, whose limbs no longer serve for walking, but assume the form of foliaceous plates, constituting at one and the same time organs of natation and respiration. Such are the limnadiæ, which have been already mentioned (Fig. 519), the apis, the branchipes, the daphniæ. It is to this group that the *trilobites* seem to have belonged: marine animals, whose fossil remains are found in the most ancient strata of the globe, but of which there exists not at present any living representative in the seas.

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* One of the valves of the carapace has been removed.

§ 577. The entomostraca are also formed only for swimming, and in youth they all possess a certain number of rigid double-oared limbs; but in the adult state they are mostly sedentary, and then the body becomes deformed in a very singular manner; in general they have but a single eye, placed in the middle of the forehead, and their respiration seems to take place over the whole surface of the body.

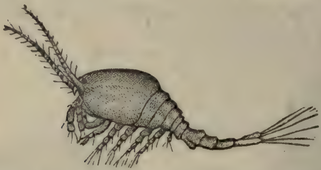

Fig. 520.—Cyclops; one of the Entomostraca.

§ 578. Some, called copepoda, are always very active, and possess large antennæ and a masticatory apparatus; these are the cyclops, or monocules (Fig. 520).*

§ 579. Others live as parasites on fishes, crustacea, &c., and have the mouth elongated in the form of a proboscis or beak, armed with style-formed appendages adapted to pierce the integuments of the animals whose juices they suck. They have been divided into the siphonostoma and the lernæa; the first have always swimming limbs, and attach themselves by means of limb-jaws having the form of hooks; the second, on reaching the adult age, present no longer any traces of locomotory organs, and have often been confounded with the intestinal worms.†

§ 580. It is also in this division of the entomostraca that we must arrange the cirrhipeda, which at first sight seem to have many analogies with the mollusca, more so indeed than with animals of the class we now describe; but in fact they are only crustacea with the body deformed after they have ceased to lead a wandering life. When young, these small beings, which are all marine, swim freely, and resemble extremely certain ordinary entomostraca, such as the young cyclops (Fig. 158); but soon afterwards they become fixed, so long as their life endures, to some submarine body, and completely change their form. It is by the back that they thus adhere, and their body, more or less pyriform and curved on itself, is enclosed, in whole or in the greater part, in a kind of shell, composed of several pieces (Fig. 521). They have no eyes, and their mouth is furnished with mandibles and jaws having the strongest resemblance with those of certain crustacea; the abdominal aspect of their body is occupied by two rows of fleshy lobes, having each long horny

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* The Entomostraca play an important part in the great economy of nature. They form the especial food of many valuable fishes of the family salmonidæ, clupeidæ, and coregoni; and it is evident, from the remains in the limestone strata, that they abounded, and were perhaps of a larger size generally, in the seas and fresh waters of the ancient world.—R. K.

† A species of lernæa attacks the gills of the salmon during its residence in fresh waters, but seems to perish when the fish return to the sea.—R. K.

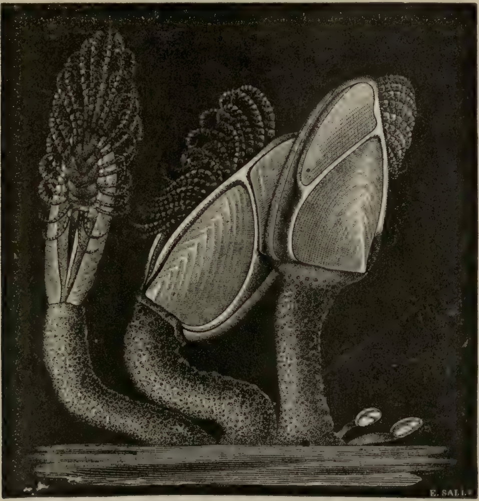

Fig. 521.—Anatifæ; Barnacles.

appendages, furnished with cilia, and composed of a great number of joints. These kinds of arms or cirrhi, numbering twelve pairs, are curved on themselves, and the animal constantly protrudes and withdraws them by the opening of its sheath or case. At the extremity of this series of organs is found a kind of tail, having the form of a long fleshy tentacle, at the base of which is the anus. Their nervous system is composed of a double chain of ganglions, disposed exactly as in the other articulated animals. They have a heart, lodged in the dorsal part of their body, and they breathe by branchiæ whose form varies.

The cirrhipeda are divided into two families—the anatifæ and the balani.

The Anatifæ (Fig. 521)—called also lepas anatifera and Barnacle—are enclosed in a kind of compressed mantle, open on one side, and suspended by a long fleshy peduncle; sometimes this mantle is almost entirely cartilaginous: at other times it is covered by five testaceous plates, of which the two principal ones bear some resemblance to those of a mussel. The common anatifa dwells in our seas, and is frequently found attached to rocks, to the keels of ships, and to pieces of floating timber. It has been the subject of most absurd fables; some coarse resemblance of its shell to a bird gave origin to the silly tale that from these animals came the goose called barnacle.

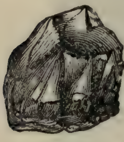
Fig. 522. Balanus, or Acorn Shell.

The Balani or sea acorns (Fig. 522) abound on the rocks of our seas, and are contained wholly in a kind of shell, generally conical, and very short, fixed by its base, and composed of several lappets articulated with each other: the opening of this tube is occupied by two or four moveable valves, between which is found a fissure destined to give passage to the cirrhi.

§ 581. Finally, the division of crustacea called xiphosura is composed only of a single genus, that of the limulus, whose structure is most anomalous. These are large crustacea, whose bodies are divided into two parts; the first, covered by a semicircular buckler, has eyes, antennæ, and six pairs of feet surrounding the mouth, which serve at the same time for walking and for mastication (Fig. 142); the second portion of the body, covered by another buckler, almost triangular, carries beneath, five pairs of swimming limbs, whose posterior aspect is covered with branchiæ; and it terminates with a long styliform tail. These singular animals inhabit the Indian Ocean and the coasts of America; they are known by the common name of Molucca crabs.

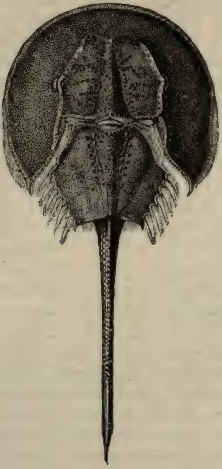

Fig. 523.—Limulus, or Molucca Crab. King Crab.

[" As there is scarcely a subject more interesting in natural history than that part of it which treats of the various metamorphoses which *all* animals undergo in their progressive growth from the embryonic to the adult condition, I have ventured to subjoin the observations made on this subject by a former most esteemed student of mine, and a careful observer.* They refer, no doubt, especially to the class cirrhipeds, but *mutatis mutandis* apply to all. In my late inquiries into the dentition of the salmon, other singular facts have come out, plainly disproving the opinion of M. Valenciennes, that 'Naturalists have only to do with the adult forms.' For all these adult forms or species are included in the history of the young, as I have proved with regard to the salmonidæ; whilst all transcendentalists since the time of Goethe and Oken have known that the larva conditions of many living species typify, or are types of, adult forms or species now extinct; that is, of the adult forms of the fossil world. Thus it is that the history of the organo-genesis, of the metamorphoses of the young, elucidates the history of the organic world, past and present, connecting them together into one great whole, the accomplishment of one vast design. The laws of deformation, even in man, are as yet but little understood. One thing is certain; namely, that for the future zoology cannot be based on any exclusive method or mode of research, but must seek for its illustrations and views in the entire range of descriptive and philosophical anatomy, to which must be superadded the careful observation of external characters. Here are Mr. Goodsir's remarks:—

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* Mr. Henry Goodsir, in the *Edinburgh Philosophical Journal.*

'There is no set of animals which has caused greater annoyance to systematists than the cirrhipeda.

'They were first arranged by Linnæus along with the testaceous mollusca. Cuvier at first followed this arrangement, but latterly placed them in a distinct class by themselves, between the mollusca and articulata. Lamarck, Latreille, M'Leay, and other authors, followed this latter arrangement; the two last authors acknowledging, at the same time, their closer connexion with the articulata.

'The decision of this important question, however, was left to our countryman, Mr. J. V. Thompson. This gentleman having obtained some minute mussel-like animals, at first considered them to be nondescripts belonging to the crustaceans, but on a further examination, and by keeping a few of them alive in glass vessels of sea-water, he was soon enabled to make out their nature and relations satisfactorily. To use Mr. Thompson's own words—'They were taken on the 1st of May, and on the night of the eighth the author had the satisfaction to find that two of them had thrown off their exuvia, and wonderful to say, were firmly adhering to the bottom of the vessel, and changed into young barnacles.' The above-mentioned statements set at rest, in a great measure, the previous discussions as to the position of the cirrhipeds in the animal kingdom.

'In the beginning of March of the present year (1843), while Professor Reid* of St. Andrews and myself were watching the movements of some very large balani (*Balanus Tintinnabulum*), we observed a few of them ejecting with considerable force a great quantity of small granules every time the cirrhi were retracted. No great attention was paid to this at the time. Next day, however, we were astonished to find the basin in which the balani were confined swarming with an innumerable number of extremely minute but very active animals, when it immediately struck us that these must have been the young which the balani were throwing off the day before. On placing one of these animals under the microscope, we expected to find one of those mussel-like animals described by Thompson ; but instead of that, it had an almost exact resemblance to the young of the genus *cyclops.* To make sure that there had been no mistake, one of the adult balani was opened, when the large cavity of the mantle was found to be filled with the granules which we had formerly seen ejected. A few were placed in a watch-glassful of sea-water under the microscope. They were quite motionless, of an ovoid shape, sharper at one extremity than the other. The eye, or rather what was considered to be the eye, was observed a little before the middle line, and near to the superior edge. In the course of a short time, a few began to make some efforts to escape. After they had done so, they were found to resemble, in their external appearance, the young cyclopides alluded to above. At first, the efforts to escape were feeble, but latterly they became more violent ; and by means of the tail, which was suddenly and forcibly jerked upwards and downwards, the membranes which contained them were burst on the abdominal surface, upon which the young animal escaped. It was some time, however, before the extremities were completely freed. In the course of ten or fifteen minutes after they had been taken from the body of the mother, these young animals were all free, and the empty sacs were lying amongst them. They have a striking resemblance, in their external appearance, to the larvæ of the cyclops ; and if we had not had the certain evidence of having seen them taken from the body of the mother, we would have pronounced them young cyclopides.

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* Dr. Reid was my student and assistant for several years; he was a diligent anatomist.—R. K.

'After many fruitless endeavours, we found it impossible to preserve them alive for any length of time, and were, therefore, disappointed in our expectations of seeing them undergo their metamorphoses. We were, therefore, uncertain whether they underwent a first and second metamorphosis, and changed first into the mussel-like form described by Thompson, and then into the parent form, or were simply metamorphosed into the parent form. Seeing that this is a distinct species from that described by Mr. Thompson, it is impossible to decide this question until farther observations have been made. Having been fortunate enough, however, in making a series of observations of the same nature on the young of the *balanus balanoides,* which are recorded above, it will now be seen that this question is already decided, viz., that the balani must undergo two changes of form, or perhaps more, before arriving at a state of maturity.

'We will now proceed to give a short description of the larva of this species.

'When viewed from above, the body of the animal is found to be pyriform, with the anterior edge rounded, and the posterior extremity ending by means of a point. The whole body consists of three segments: the first forms the greater part of the body; the two last are minute. Two long unarticulated extremities project from the anterior edge on either side of the mesial line, arising, apparently, from the abdominal surface of the body. Two short antennæ arise also from this edge, immediately on each side of the above-described extremities.

'The eye is situated a little behind the anterior edge, and in the mesial line of the body.

'Two very strong thick legs arise from each side of this first segment of the body. These are bipartite, each division arising from a pedicle common to both, which consists of three segments. The divisions themselves are apparently unarticulated, but are armed with a number of very strong spines.

'The second segment of the body is minute. The third and last is also minute and pointed, and is armed with three strong spines, which are bent to one side (the left side), that nearest the right side being the shortest.

'All of these larvæ swim after the manner of the monoculi, by short and sudden jerks. They propel themselves by means of the two pairs of spined extremities. The tail is also in constant motion.'—H. G., in *E. P. Journal.*

"By the minute and prolonged study of the metamorphoses of animals, we thus prove that these so-called imperfect forms, or forms *in transitu,* are the permanent forms of adult extinct and recent animal beings. Thus we upset the theory of the transmutation of species, and creation of new forms; for these forms are embraced in the embryonic, and require but time and circumstances for their full development: nevertheless, I willingly concede to my esteemed friend, M. Valenciennes, that the naturalist is only interested in *adult forms,* these being the highest specializations to which animals attain: it holds even in man himself."*—R. K.]

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* See my *Manual of Artistic Anatomy.* Renshaw, London.

THE SECOND SUB-DIVISION.

OF THE ANNELIDES, OR ANNULATED ANIMALS.

THE VERMES, OR WORMS.

§ 582. In these animals the annulated division of the body becomes less and less marked; every structure becomes as it were degraded in proportion as we leave those most resembling the articulated to those approaching the zoophytes; the limbs disappear, and the nervous system becomes less and less distinct, or loses its importance, and the structures simplify more and more. Their most remarkable feature is the elongation of their bodies, and they form five distinct classes; namely, the annelides, rotatoria, turbellaria, helminthides or intestinal worms,* and cestoids.

OF THE ANNELIDES.

§ 583. The class is composed of worms having a multigangular nervous system, and a vascular apparatus for the circulation of the blood.

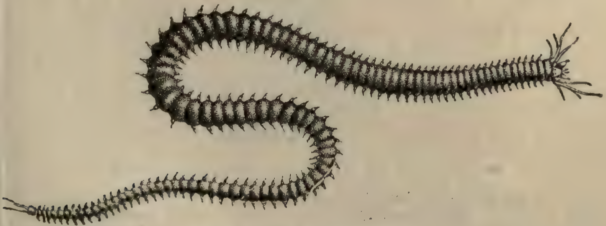

Fig. 524.—Nereis; Mudworm.*

Their bodies are always elongated, soft, and divided by circular folds into a great number of rings; sometimes the head is distinct, sometimes it is wanting; and generally along the sides of the body they have a long series of hairs in bundles, supported on fleshy tubercles, taking the place of feet (Fig. 524). Frequently we find two of these organs placed one above the other, on either side the different rings of the body (Fig. 413); at other times these bristle-carrying tubercles are reunited, and there is found at the base of each a long, soft cylindrical appendix called cirrhus (*c*, Fig. 525); sometimes the place of the feet is marked by merely a few stiff hairs, whilst in others all traces of limbs have disappeared. These hairs or bristles serve as instruments of defence and of locomotion; they are in general sharp, and calculated to attach the animals to any soft body with which they come in contact. In the annelides, which have no bristles, there exist at the extremities of the body, suckers which answer the purpose.

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* Entozoa.

† Called mudworm by the fishermen of Dover, who use them as bait for the white mullet, numbers of which are taken by angling at the mouth of the harbour.—R. K.

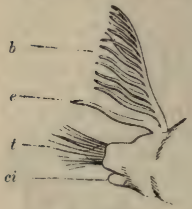

Fig. 525.*

§ 584. Their nervous system consists of a chain, single or double, of very small ganglions, extending from one extremity of the body to the other. Most have a few dark spots, which seem to be the eyes, and the head is usually provided with a number of filaments analogous to the cirrhi of the feet, and called antennæ and tentacular cirrhi (Fig. 527), which seem to be organs of touch. The mouth is on the inferior aspect of

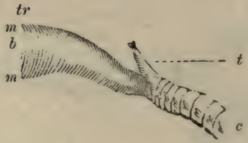

Fig. 526.—Head and Proboscis of a Glycera.†

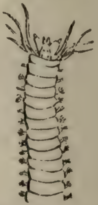

Fig. 527.—Head, &c., of a Nereis.

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* Feet of an Annelid of the genus Eunice :—*t*, setigerous tubercle; *e*, dorsal cirrhus; *ci*, inferior or ventral cirrhus; *b*, branchia.

† *c*, anterior part of the body; *t*, the head; *tr*, proboscis; *b*, buccal opening; *m*, jaws.

the head, or the anterior extremity of the body, when there is no distinct head; it is often armed with a protractile proboscis (Fig. 526), and with jaws having the form of horny hooks. The intestine is straight, simple, or furnished with cæca, placed on either side; the anus is at the extremity of the body.

The blood is almost always red; sometimes it is green, and at others scarcely coloured; it circulates in a complex system of vessels, varying in different species; of these vessels some are contractile, and perform the function of a heart; others those of arteries and veins.

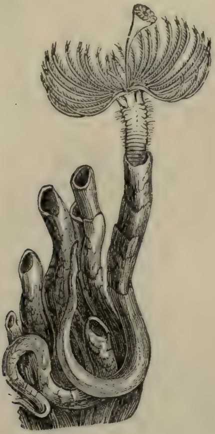

Fig. 528.—A Group of Serpulæ.

The respiration of these animals is generally aërian, but sometimes aquatic, and in this case it is performed by means of external branchiæ, whose form and arrangement vary much; sometimes they resemble little trees or leaves, and are fixed above the feet on each side of the back, as in the arenicola (Fig. 56); at other times they resemble bunches of feathers, and unite in a corona around the extremity of the body, an arrangement of which we have an example in the serpula (Fig. 528).

§ 585. Most of the annelides live in the sea, and several construct as dwellings a long tube, formed either of calcareous matters secreted by the skin (Fig. 528), or consisting of sand and fragments of shells, agglutinated by means of a gelatinous substance; several, as the arenicola, plunge deeply in the sand (Fig. 56); others conceal themselves under stones; finally, there are annelides, as the leech, which live in fresh waters: so also does the naïs, which more resembles the earthworm; and these last, called by zoologists *lumbrici*, are land animals.

CLASS OF THE ROTIFERA.

§ 586. These beings, which have been often confounded with the infusoria, are nevertheless quite distinct. Their structure is very complex, and we owe the discovery of this fact to the microscope, and to the profound researches of M. Ehrenberg, of Berlin. Before his time they were thought to be animals

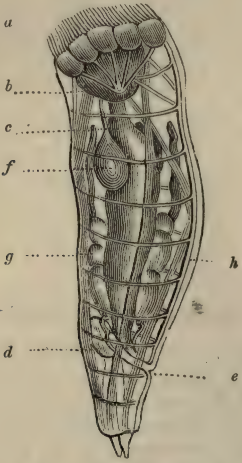

Fig. 529.—The Hydatina.*

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* Anatomy of the Hydatina, a microscopic animalcule next the Rotifera: *a*, vibratile cilia; *b*, fleshy mass surrounding the mouth and moving the jaws; *c*, the stomach; *d*, the cloaca; *e*, the anus; *f*, salivary glands; *g*, ovaria; *h*, the muscles.

composed of animated jelly, nourished by imbibition; now it is no longer the simplicity of their structure which surprises us, but the complication of their organization, wholly microscopic.

These animalcules are met with in stagnant waters. Their body is semi-transparent, and presents traces sufficiently distinct of annular divisions. The mouth occupies the anterior extremity, and on each side, or even all around the orifice, may generally be seen vibratile cilia, the rotatory movements of which are extremely remarkable. Almost always the pharynx (*arrière bouche*) is furnished with powerful muscles, and armed with lateral jaws. The digestive canal is straight; it extends from one extremity of the body to another, and has generally towards the middle an enlargement representing the stomach of these small beings; often may be seen, on either side of this tube, bodies apparently glandular, and at its posterior extremity a sort of cloaca, in which terminate the oviducts. A great number of muscles have also been dis-

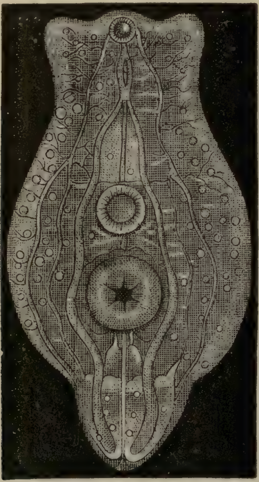

Fig. 530.—Fluke Worm; Fasciola Hepatica.

covered in these animalcules, and even a ganglionary nervous system.

§ 587. The rotifera—wheel bearing animals—(Fig. 177), one species of which has become celebrated by the experiments of Spallanzani on the suspension of life which follows its drying up, may be taken as a type of the class. Their body is elongated, and is terminated anteriorly by two small coronæ of cilia, which at the will of the animal are withdrawn into the interior or expanded externally, and which by their vibrations produce the image of two small wheels turning rapidly on their axes. They terminate in a bifurcated and articulated tail, by which they attach themselves to bodies on which they wish to rest; finally, two small red points seem to represent the eyes. These animalcules swim with the greatest vivacity, and lay oval eggs.

§ 588. Other animalcules, called branchions, resemble the rotifera in the general mode of their organization, but merit notice by reason of a sort of carapace, or shell, with which their body is covered. In several of these small beings the shell or covering is even bivalve, and recals very much that of certain crustacea, such as the cypris and daphnia.

CLASS OF TURBELLARIA.

§ 589. This class ought to comprise a certain number of vermes, whose body, more or less compressed, presents scarcely any traces of annulation, and is covered with extremely fine vibratile cilia. In general they have no anus, and their digestive apparatus is ramified, and terminates in a *cul-de-sac;* their nervous system is composed of two lateral cords, terminating anteriorly in a pair of cerebroid ganglions, and they have distinctly-formed bloodvessels. Some, as the *nemertes* and the *planaria,* live in water. Others, as the fluke (Fasciola Hepatica, Fig. 530), are parasites, and live in the interior of other animals.

CLASS OF HELMINTHES, OR NEMATOÏDS.

§ 590. This division is composed of a part of those animals sometimes called *intestinal worms,* by reason of their living generally as parasites in the intestinal canal of man and of most other vertebrata.* The nematoïds (helminthes) have the body cylindrical, and attenuated at the two extremities; exteriorly they greatly resemble earth-worms, and also, as in the annelides, their intestinal canal is simple, and extended from one extremity of the body to the other; but their nervous system is rudimentary, and their blood is colourless.

The principal genera of this class are, the ascarides (Fig. 178), the strongyli, and the filaria.

CLASS OF CESTOÏDS OR TÆNOÏDS.

§ 591. The cestoïds are also intestinal worms, but they differ from the nematoïds (*helminthes*) greatly in their form and mode of organization, and more resemble the turbellaria. They have the body flattened, much elongated, and divided into a great number of segments, which gives them the appearance of a long ribbon folded transversely. Their nervous system is rudimentary, and their intestinal canal appears to be replaced by two longitudinal vessels occupying the sides of the body. They are *hermaphrodite,* and each ring (segment) of their body possesses a complete reproductory apparatus. The *tænia,* or solitary worm, belongs to this division (Fig. 531).

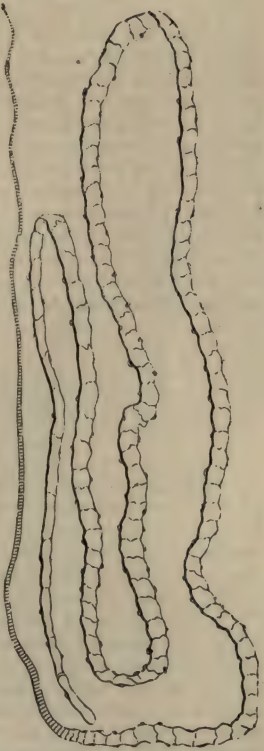

Fig. 531.—Tape Worm, Tænia.

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* It would seem from the researches of Van Beneden and others, that these parasitical animals are introduced into the bodies of others from without, in the condition of ova in fact, and that their future development depends on their reaching the *habitat* suited to them.—R. K.

DIVISION OF THE MOLLUSCA, OR MALACOZOARIA.

§ 592. The division of the mollusca is composed, as we have already said, of a considerable number of animals which have neither a cerebro-spinal system nor an internal skeleton, and which resemble in these respects the articulated animals, but not having, as these have, the body divided into rings, nor the ganglions (nervous) reunited into a long median chain placed on the ventral aspect of the body. They are distinguished also from zoophytes by the disposition of the organs of relation being arranged in pairs, and in general they have the mouth and anus more or less close to each other. Moreover, they differ much from each other, and are divided into two principal series,—namely, the mollusca properly so called, and the molluscoïdes or tunicata.

SUB-DIVISION OF THE MOLLUSCA

PROPERLY SO CALLED.

§ 593. In this group the nervous system is always composed of several ganglions, reunited by medullary cords, so as to form a sort of double collar, more or less closely around the gullet, but not prolonged posteriorly like a sub-intestinal chain, as in the annulated animals.

The general form of these mollusca is extremely variable. Their body is always soft, and in a small number only (the sepia, for example) there exist in the interior some solid non-articulated pieces, serving rather to protect the viscera than to furnish to the locomotory apparatus levers and points of support. The muscles are fixed directly into the integuments, and seem to act only on the point into which they are inserted; and thus the movements of the animal are slow and ill directed. In a small number of these beings (the sepia, for example) there are flexible and elongated appendages (Fig. 185), intended for locomotion, but in most instances the animal cannot displace itself but by successive contractions of various points of the lower surface of its body; and even when there exist limbs, these organs are reunited in a group at one extremity of the body, and never disposed in a symmetrical series, as in the vertebrate and articulate animals.

The skin of the mollusca, always soft and viscous, often forms folds which envelope more or less completely the body; and this disposition has induced zoologists to give the name of mantle to that portion of the integument generally furnishing these expansions. This mantle is often entirely free, forming two large veils or coverings concealing all the rest of the animal, or these two laminæ unite so as to form a tube; but at other times it consists only of a kind of dorsal disc, of which the edges alone are free or surround the body more exactly under the form of a sac.

§ 594. In general the soft skin is protected by a kind of stony or hard cuirass, called shell. It is a tissue which has some analogy with that of the epidermis, which constitutes this envelope. The follicles lodged generally in the edges of the mantle, deposit on its surface a half-horny matter, mixed with carbonate of lime in greater or less proportions, and is moulded over the subjacent parts, and next solidifies. The lamina thus formed thickens and grows by the successive deposit of new matter. Its surface is not stony, but resembles a kind of epidermis, and is known by the name of *drap marin*, or sea-cloth; sometimes it preserves a horny consistence throughout its whole thickness, but in general the proportion of carbonate of lime which it encloses gives to it a stony hardness. Its inner surface is frequently more dense than the rest, and presents a peculiar structure rendering it glassy, lustrous, and pearly. Sometimes the shell remains always enclosed in the thickness of the skin of the animal; but generally it is external, and even passes beyond the edges of the mantle, so as to furnish to the animal perfect shelter. The name of naked mollusca has been given to those which are without shells, or which have only an interior one, and the name of conchifera to those in which the shell is visible externally.

The manner in which this shell grows may be readily understood. If we examine the shell of an oyster, for example, it will be found to be composed of a number of superimposed laminæ, which can be separated by means of heat. These plates have been formed successively by the mantle of the animal, which they cover, and consequently the most external is the oldest, or first formed, and the smallest; each new plate deposited passes beyond the plate situated above it, so that the shell as it grows in thickness also enlarges rapidly. In general, the distinction of laminæ whilst forming is less marked, and the new matters are often deposited only on the edge of the shell, and in such a way that their molecules correspond exactly to the molecules of the part already consolidated; this gives to the whole a fibrous structure. Colours the most varied and most agreeably disposed ornament these shells, and often vary with age. Very generally they are altogether superficial, and seem to depend on a sort of dyeing process produced by the skin of the animal, which is painted in a manner corresponding to its envelope. The colouring matter appears to be deposited on the shell at the moment of its formation; it is also more lively as the shell is younger; it is produced by the edge of the mantle. In fact, if a shell be broken, and the animal happens to repair this accident, the part newly formed is always white where it has not been in contact with the edge of the mantle; and if it corresponds with this edge, it assumes the colour which this presents at the point of contact. Thus when the edge is spotted, corresponding spots are found upon the edge of the shell; and as this elongates, these spots become confounded with those already formed, and produce lines perpendicular to the striæ of increase, or do not unite with them, and remain insulated, according as the mantle remains immovable, preserving with the margin of the shell the same relations; or, on the other hand, that by the movements of the animal it often changes its position. Sometimes the secretion of colouring matter also varies with age, and accidental circumstances may equally modify it. Light, for example, exercises over the phenomenon a very remarkable influence, and not only the shells which are the most exposed to the action of this physical agent are generally the most brilliantly coloured, but when the mollusc lives fixed on a rock, or partly concealed under a sponge or some other opaque body, the portion of the shell thus placed in obscurity is always paler and duller than that exposed to the contact of the sun's rays.

§ 595. The digestive apparatus of these animals is strongly developed. There exists always a large liver, and often we find salivary glands and organs of mastication; but the intestines are never supported by a mesentery. Their blood is colourless, or slightly bluish, and circulates in a very complex apparatus, composed partly of arteries and of veins, and partly only of lacunæ. A heart, formed of a ventricle, and of one or of two auricles, is found in the course of the arterial blood, transmitting this liquid into all parts of the body, from whence it returns to the organ of respiration by canals more or less incomplete. We sometimes also meet with, at the base of the vessels entering the organ of respiration, contractile venous reservoirs called *pulmonary hearts.*

With regard to the arrangement of the organs of respiration, it varies too much to allow of us describing it in this place. We shall therefore only say that they have sometimes the form of lungs, at others that of branchiæ or gills.

§ 596. In like manner we cannot say anything generally of the structure of the organs of sense, which, however, are always less complete than in vertebrate animals. Certain mollusca seem to be gifted only with the senses of touch and taste; but a great number have eyes, whose structure varies, and in many of them there even exists an apparatus for hearing; but none have yet been found possessing a special organ for smell.

The mollusca spring from eggs, and never multiply by granulations, as happens in most of the molluscoïdes, but sometimes these eggs are hatched externally, sometimes in the interior of the body of their parent, which may then be said to be ovoviviparous.

§ 597. The sub-division of the molluscs properly so called, is composed of four principal groups or classes, called the cephalopoda, gastropoda, pteropoda, and acephala. We shall now make known their more prominent characters.

CLASS OF THE CEPHALOPODA.

§ 598. This class is composed of mollusca of an extremely odd form, for their head is placed between the trunk and the feet, or tentacula, serving for locomotion; and when they walk, it is with the body upwards and the head downwards that they draw themselves along the soil (Fig. 185); in fact, it is on the head, around the mouth, that their feet are inserted; and hence their name of cephalopoda. The trunk of these animals is covered by the mantle, which has the form of a sac, sometimes almost spherical, at others elongated, open in front only, and enclosing all the viscera (Fig. 533, *o*). The head projects through this opening; it is round, and is generally furnished with two large eyes (Fig. 10), of a structure very analogous to that of the eyes of vertebrate animals. The mouth occupies the middle, and is armed with two jaws. Finally, around this opening is a corona of flexible fleshy appendages (Fig. 532), named, indifferently, arms or feet, and which merit equally both names, for they are at once the instruments of prehension and of locomotion.

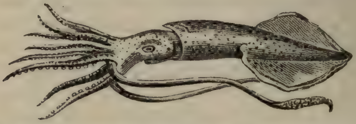

Fig. 532.—Common Calmar (the Loligo Sagittarius); a Cuttle Fish.

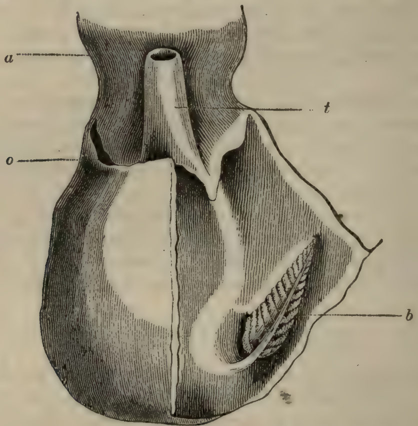

Fig. 533.—Gills of the Poulpe (Octopus); Sepia, or Cuttle Fish.*

§ 599. The cephalopoda are essentially aquatic animals, and they in consequence breathe by gills. These organs are found concealed in the mantle, under a particular cavity (Fig. 533), whose walls dilate and contract alternately, and whose interior communicates with the exterior by two openings. The one (*o*) in the form of a fissure serving for the entrance of the water; the other, prolonged into a tube or funnel (*t*), serving for the escape of the water and of the residue of the food. Each gill (*b*) has the shape of an elongated pyramid, and is composed of a great number of membranous lamellæ, placed transversely, and fixed on either side of the median

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* The body of an Octopus, as seen on its inferior surface (the mantle is laid open in the median line and on one side, and is turned outwards to show the interior of the respiratory cavity):—*a*, base of the head; *t*, the tube by which the water leaves the respiratory cavity; *o*, one of the two lateral openings by which the water penetrates into this cavity; *b*, one of the branchiæ, or gills.

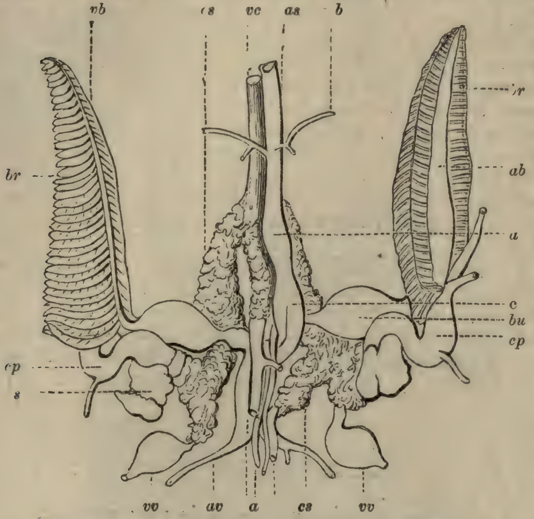

Fig. 534.—Organs of Respiration and Circulation in the Cuttle Fish.*

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* *c*, the aortic heart, the superior extremity of which is continuous with the superior aorta (*as*), distributing the blood to the head, &c.; *b*, the branches of this vessel; *a*, the inferior aorta, presenting a bulb at its origin, and soon dividing into two branches (*vv*); *vc*, vena cava, whose walls are covered by the spongy bodies (*cs*); *vv*, veins of the viscera proceeding to open into the two branches of the vena cava; *cp*, venous sinuses or branchial hearts; *s*, enlargement of the base of the branchial arteries; *br*, gills, *ab*, branchial artery; *vb*, branchial vein; *bu*, bulb of the branchial veins situated near the termination of the vessels in the heart, and constituting the auricles.

stalk. The number of gills varies, and this difference is characteristic of the two great natural divisions of which the class is composed. In the octopus, the sepia, and the loligo, there exists only a single pair; but in the nautili there are two pairs.

§ 600. The heart is situated between the gills, in the median line of the body, and is formed of a single ventricle (Fig. 534, *c*). The blood reaches it from the branchiæ by the branchial veins (*vb*), whose openings are provided with valvules, and thus penetrates into the arteries which spring from the organ, and are distributed to the body. This liquid passes afterwards into a venous system composed partly of vessels properly so called, and partly into cavities without proper walls, hollowed out between the organs; thus the space comprised around the anterior portion of the digestive apparatus performs the office of a venous sinus, and the principal nervous ganglions, as well as various glands, are bathed in the blood.

Finally, the nourishing fluid which thus returns from the different parts of the body, traversing the visceral cavity, or passing in veins properly so called, reaches at last a large median trunk, whose branches proceed to the organs of respiration, but generally penetrate first into a contractile reservoir situated at the base of each of these organs. These reservoirs push the blood into the branchial vessels, and consequently there are in these animals two pulmonary hearts as well as an arterial; but this arrangement, which exists in all the cephalopoda with two gills, is wanting in the tetra-branchial cephalopoda.

§ 601. The digestive apparatus is very complex. The mouth is surrounded with a circular lip and with two mandibles, placed vertically one over the other. They resemble strongly the bill of the paroquet, and are moved by powerful muscles. There are salivary glands, highly developed, several stomachs, and a large liver. The intestine terminates in the branchial cavity at the base of the funnel, by which the water is expired, and communicates with a very singular secreting organ, which in the cephalopods with two gills produces an abundance of a black liquid, to which the name of *ink* has been given. The excretory canal of this gland opens near the anus; and when the animal is in danger, it ejects by the funnel a sufficiency of the dark fluid to colour the surrounding water, and thus escapes from the sight of its enemies. It is the *ink* of one of those cephalopods, *the sepia,* which is employed in painting under the name of sepia; and several authors think that China ink is an analogous

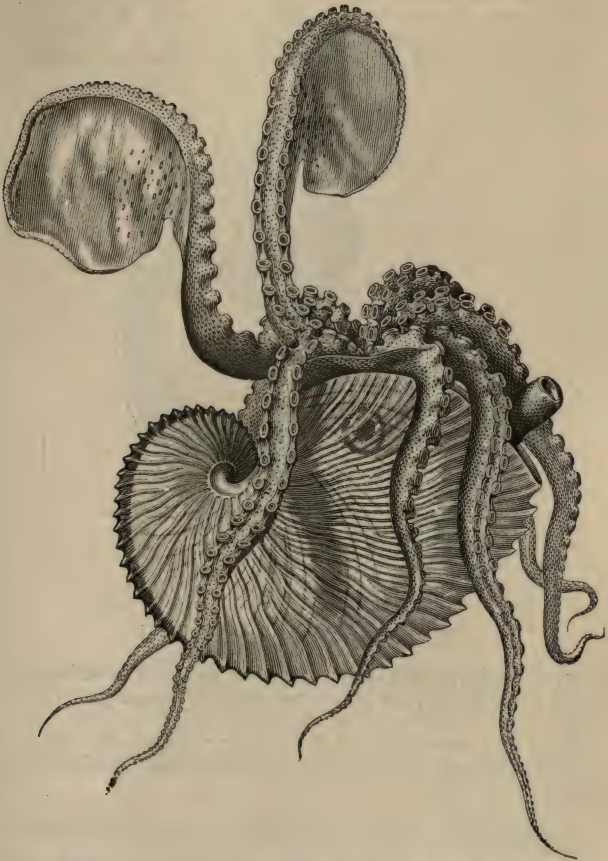

Fig. 535.—The Argonaut (Argonauta), in its shell. The Paper Nautilus.

substance.* The tetrabranchiate cephalopods have no such organ.

§ 602. We have said above that the mollusca have no solid articulated framework comparable to the skeleton of the vertebrata. Nevertheless, in the cephalopoda we still find vestiges of something analogous; for there is in the head a cartilage which not only protects the brain, but also spreads out in different directions, furnishing points of insertion to the different muscles of the animal. It is also to be observed that the abdomen of these animals is in general supported by a sort of internal shell, which in the loligo is horny, but in the sepia is of a calcareous nature, and is called the bone of the sepia.

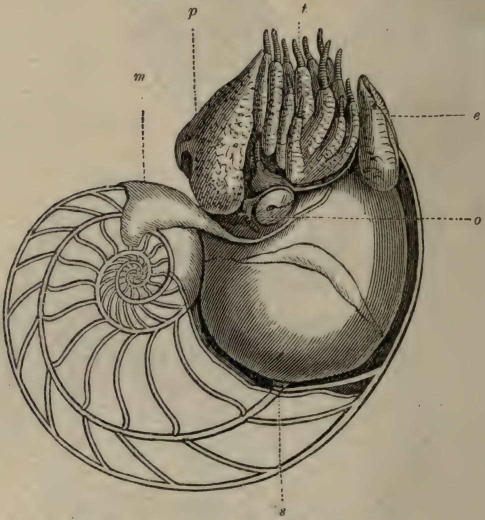

Fig. 536.—Nautilus; the Pearly Nautilus.†

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* It would seem, however, that the colouring matter employed in the fabrication of China ink is nothing but carbon, minutely divided.

† In this figure the shell is represented open:—*t*, the tentacula; *e*, the funnel; *p*, the foot; *m*, a portion of the mantle; *o*, the eye; *s*, the syphon.

§ 603. The disposition of the organs of locomotion and prehension, fixed around the mouth, varies in these mollusca.

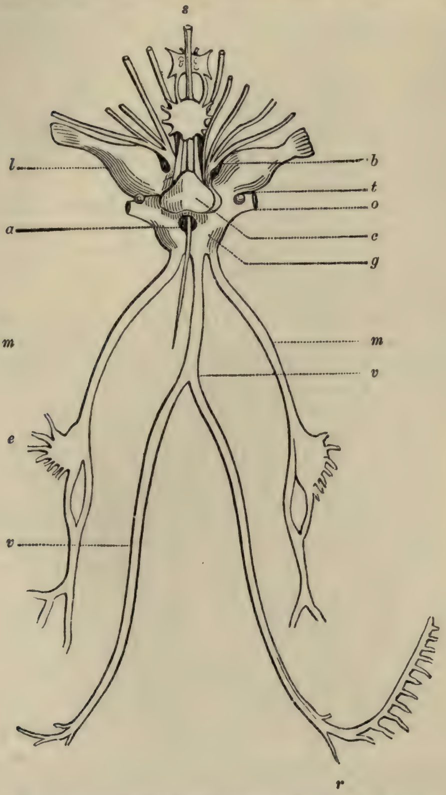

Fig. 537.—Nervous System of the Cuttle Fish (Sepia).*

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* *a*, the nervous collar surrounding the gullet, the course of which is indicated by a bristle (*s*); *c*, the nervous mass situated before the gullet, and generally called brain: its superior surface is surmounted with a very large cordiform tubercle, and there proceed from its anterior part nerves, which soon terminate in a circular ganglion, which in its turn gives origin to

In the dibranchiate cephalopodes there is a corona of large fleshy tentacula, whose internal surface is provided with suckers, by means of which they attach themselves with much force to the bodies they lay hold of (Fig. 185). In the poulpe (octopus) there are eight of these appendages, and in the sepia ten; sometimes two of these enlarge like oars or membranous veils, as in the argonaut (Fig. 535), or elongate so as to become filiform, as in the calmar (Fig. 532), and especially in the calmaret (Fig. 10). In the tetrabranchiate cephalopodes these appendages are all slender, without suckers, and extremely numerous (Fig. 536).

§ 604. Most of the mollusca of this class are remarkable for the development and perfection of their eyes, which greatly resemble those of vertebrata. Several have also an auditory apparatus, but this organ is reduced to a small membranous sac, receiving a nerve.

Finally, the nervous system of these animals is more complex than in the other mollusca, and the various ganglions grouped around the gullet have a tendency to coalesce into a single mass. The medullary collar so formed is composed of a pair of cephalic ganglions, whence arise the optic nerves, &c.; of a pair of ganglions, situated more forward, but under the gullet, and furnishing the nerves of the tentacula (Fig. 537); finally, of a pair of thoracic ganglions, giving origin to the nerves of the mantle, and to two cords which, proceeding backwards, form on each side of the abdomen a ganglion, from whence arise the branches destined for the heart, gills, &c.

§ 605. All the cephalopodes are marine; they are very voracious, and live chiefly on crustacea and fishes, which they seize with their supple and vigorous arms, and whose flesh they easily devour by means of their sharp mandibles. Some of these animals are lodged in shells turned on themselves: such are the argonaut and the nautilus; but some naturalists think that the first does not itself form the cal-

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another pair of nerves which descend under the mouth so as to embrace the gullet anew, and to form there a small anterior ganglion, whence arise the labial nerves; *b*, tentacular ganglions, whence arise the nerves of the arms; *o*, optic nerves, arising from the lateral parts of the brain, and soon swelling into a large ganglion; *t*, small venous tubercles, situated on the origin of the optic nerves; *g*, œsophageal or ventral ganglion; *v*, great visceral nerve, one of the branches of which has on it an elongated ganglion (*r*), and penetrates into the gills; *m*, nerves which arise also from the post-œsophageal ganglions, and which have on their passage a large star-shaped ganglion (*e*), whose branches proceed to the mantle.

careous covering, but lives as a parasite in the shell of another mollusc.

This class comprises the octopus (Fig. 185), the argonaut (Fig. 535), the sepia, the calmar (Fig. 532), the calmaret (Fig. 10), the nautilus (Fig. 536), &c. With these are arranged the ammonite shells, which have some analogy with those of the nautilus, but are found only in a fossil state.

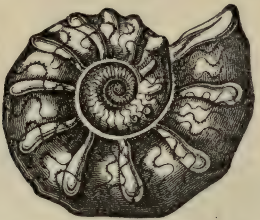

Fig. 538.—The Ammonite; an extinct mollusk.

CLASS OF THE GASTEROPODA.

§ 606. The gasteropoda are molluscs which have a head, and move by means of a fleshy disc or foot placed under the belly (Fig. 539), or of a fin formed by the same part of the body (Fig. 543): this class, which has as its type the snail, is very numerous, and is composed chiefly of animals lodged in a single shell, having generally the form of a cone, or rolled into a spiral; some species are, on the contrary, entirely naked, as the slug. The body is elongated, and ter-

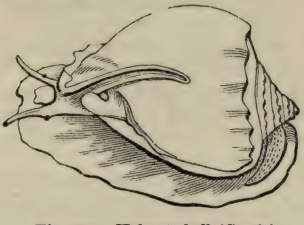

Fig. 539.—Helmet shell (Cassis).

minated anteriorly by a head more or less developed, in which is the mouth, provided with fleshy tentacles, varying in number from two to six; the back is covered with a mantle prolonged more or less backwards, under the form of a membranous sac, and which secretes the shell; finally, the belly is covered underneath by the fleshy mass of the foot. The viscera, lodged on the back, occupy the upper part of the buckler or cone formed by the shell, and remain always enclosed in it; but the head and foot project externally when the animal unfolds itself for progression, and re-enter into the last turn of the spire when they contract themselves;

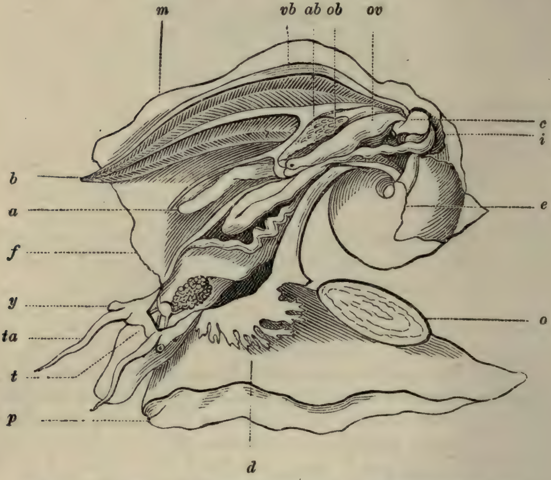

Fig. 540.—Anatomy of a Pectinibranchiate Gasteropodous Mollusc.*

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* Anatomy of the Turbo Pica, to show the arrangement of the respiratory cavity :—*p*, the foot of the animal; *o*, operculum; *t*, the proboscis; *ta*, the tentacles; *y*, the eyes; *m*, the mantle, cleft longitudinally, so as to open the respiratory cavity; *f*, anterior edge of the mantle, which, in the natural position, covers the back, and leaves an opening or large fissure by which the water reaches the gills; *b*, the gills; *vb*, the branchial vein proceeding to the heart (*c*); *ab*, the branchial artery; *a*, the anus; *i*, the intestine; *c*, stomach and liver; *ov*, the oviduct. Above the nucha is the cephalic nervous ganglion and the salivary glands :—*d*, fringed membrane bordering underneath the left side of the opening of the respiratory cavity.

thus, the size of this last part of the shell and the form of the opening are in relation with the size of the foot. In most aquatic gasteropodous mollusca in which the shell is spiral, there exists a horny or calcareous disc, named operculum (Fig. 540, *o*), which is fixed to the posterior part of the foot, and which closes the entrance of the shell when the animal retires within it.

§ 607. The heart is always aortic, and is composed of a ventricle and an auricle; it is found near the back of the animal, on the opposite side to that occupied by the reproductive organs. The arterial system is in general well developed (Fig. 53); but the venous system is always more or less incomplete, and sometimes is altogther wanting, so that the blood returns from the different parts of the body towards the respiratory organs only by traversing the lacunæ or spaces existing between the organs. It is also to be observed, that the abdominal cavity, in which are lodged all the viscera, is always thus traversed by the venous blood.

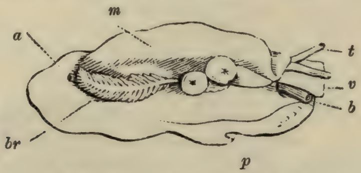

Fig. 541.—The Pleurobranchus.*

The organs of respiration are formed sometimes for an aërian respiration, sometimes for an aquatic life. In the first case, they consist in a cavity, on the walls of which the blood-vessels form a complicated network, into the interior of which the air penetrates from without by an opening under the external edge of the mantle. This kind of lung (Fig. 167) is situated on the back of the animal, and is lodged in the last turn of the spire of the shell when the mollusc is provided with such a covering. In the gasteropoda destined to breathe in water, the disposition of the gill varies; these organs are often enclosed in a cavity analogous to that constituting the lung in the preceding (Fig. 540); but at other times they are lodged between the mantle and the foot, or even on the back of the animal, so as to float freely in the surrounding liquid; as an example of the pulmonary gasteropodes, we may mention the slug and snail, which live on the land; the lymnæus or helix (Fig. 166), the planorbis (helix vortex), and the physa (the helix fontinalis), which live in stagnant waters, and ascend to the surface to breathe the requisite air. Amongst the gasteropodes provided with gills enclosed in a dorsal cavity may be observed the volutes, the buccinures, the porcelaines (Fig. 181), the heliotides, &c. The patellæ and the pleurobranchiæ (Fig. 541) carry these organs in the furrow separating the foot from the mantle; and in the doris and the eolis (Fig. 542), &c., they consist in bunches and in straps or leashes fixed on the dorsal aspect of the body.

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* *m*, the mantle raised up to show the gill (*br*); *a*, anus; *b*, mouth and proboscis; *v*, the veil; *t*, the tentacles; *p*, the foot.

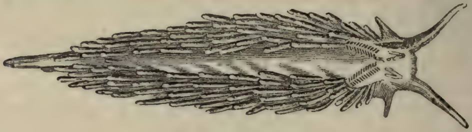

Fig. 542.—Eolis.

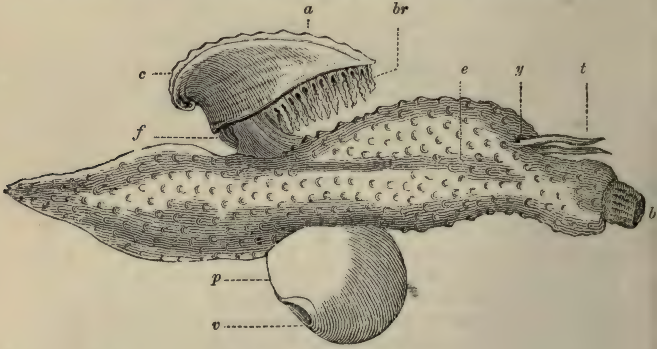

Fig. 543.—Carinaria.*

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* *b*, mouth; *t*, tentacles; *y*, the eyes; *e*, stomach; *f*, liver; *a*, anus; *c*, shell; *br*, gills; *p*, the foot; *v*, ventouse (cupping-glass-cavity air hole) situated under the edge of the foot.

§ 608. The mouth of the gasteropodes is surrounded by contractile lips, and sometimes armed with horny teeth occupying the palate. In several other animals of this class the anterior part of the gullet is very fleshy, and may be carried outwards so as to form a proboscis. Sometimes the stomach is also furnished with cartilaginous or osseous instruments adapted to divide the food; the intestine is turned on itself, and is lodged between the liver and the ovary; finally, the anus (*a*, Fig. 540) is almost always situated on the right side of the body, and is often found close to the head.

§ 609. In this class the organs of sensibility are less developed than in the cephalopodes; the tentacles which most gasteropodes carry on their forehead serve only for touch, and perhaps for smell. Their auditory organs consist only in a pair of small membranous vesicles, and the eyes, which are sometimes wanting, are very small, and of a very simple structure; they are sometimes adherent to the head, sometimes carried on the base, the side, or the point of the tentacles. Finally, the nervous system is less developed than in the preceding class, and is composed principally of a cephalic ganglion, and of a thoracic ganglion re-united like a collar around the gullet. Amongst these animals, some are terrestrial, others live in fresh water, but most are marine. In general they are formed to creep, as the slug, the limneus (Fig. 166), the cowry (Fig. 181), &c.; but sometimes they are intended only to swim, as for example the carinaria (Fig. 543).

CLASS OF THE PTEROPODA.

§ 610. The pteropoda are small molluscs having a distinct head, formed for floating and swimming by means of two fins placed like wings on either side of the neck (Fig. 184). Some are naked, and others have a shell, but their history is not of sufficient interest to induce us to dwell longer on it.

CLASS OF THE ACEPHALA.

§ 611. The molluscs which we have hitherto been considering have all a distinct head; those which remain to be spoken of are without it, and show a greater simplicity in their whole organization. Their body is entirely enveloped by the mantle, like a book in its cover; the skin of the back, in fact, is adherent only in the middle, and forms on each side a large fold, covering all the other part of the animal (Fig. 544), and sometimes even is so united to its fellow of the other side, as to leave openings only behind and before, and to form two long tubes for the water necessary for respiration. A shell, composed of two valves, covers this mantle in whole or in part, presenting superiorly a hinge, provided with an elastic ligament, by the play of which the valves are opened whenever the muscles, extending from one to the other, cease to act. The viscera are collected into a small mass, under the dorsal part of the mantle, and the ventral portion of

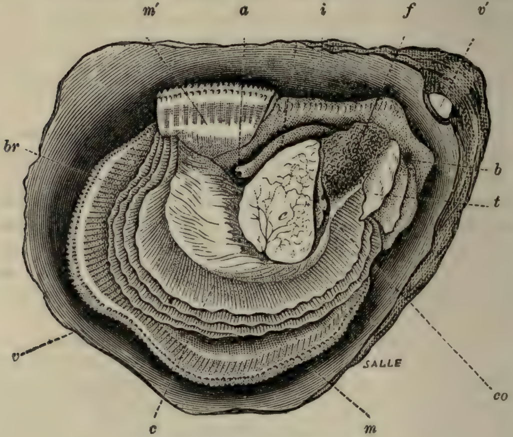

Fig. 544.—Anatomy of the Oyster.*

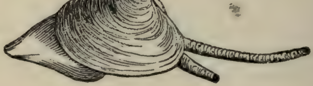

Fig. 545.—Tellina.

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* *v*, one of the valves of the shell; *v′*, the hinge; *m*, one of the lobes of the mantle; *m′*, portion of the other lobe, laid upwards; *c*, muscles of the shell; *br*, the gills; *b*, the mouth; *l*, labial tentacles; *f*, the liver; *i*, the intestine; *a*, the anus; *co*, the heart.

the body is generally prolonged so as to form a fleshy foot, having some analogy with the gasteropodes, but not so well formed for locomotion. Sometimes it is the inner surface of the mantle, as in the terebratulæ, which takes the place of the respiratory organ, and for this purpose shows a highly developed vascular network; but in general there exists a very well developed branchial apparatus, composed of two pairs of large membranous plates, finely striated, and floating between the foot and the mantle (Fig. 544). The mouth is also concealed between the folds of the mantle, and is found at one of the extremities at the base of the abdomen; it has never any teeth, but is furnished laterally with two pairs of labial prolongations, constituting laminated tentacles. The stomach is sufficiently developed, and the intestine forms around the liver circumvolutions before reaching the posterior

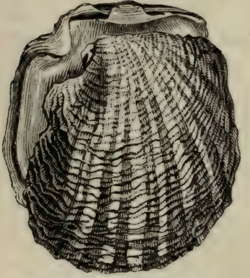
Fig. 546.—Pearl oyster.

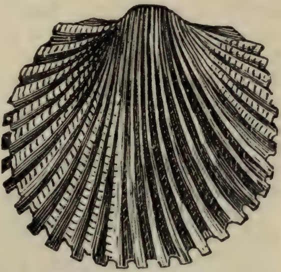
Fig. 547.—Buccardium.

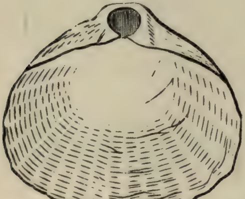
Fig. 548.—Shell of the Terebratula.

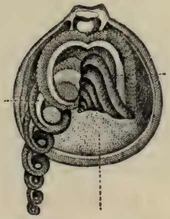
Fig. 549.—The Animal of the Terebratula.

edge of the base of the abdomen, where it terminates. The heart is generally situated above the visceral mass thus formed (Fig. 183), and is composed of an aortic ventricle, and of one or two auricles, destined to receive the blood from the gills. In general this ventricle is fusiform, and presents a remarkable peculiarity, its cavity being traversed by the rectum. Finally, the nervous system consists chiefly of two pairs of small ganglions, re-united by cords, but very distant from each other, and placed the one above the mouth, the other under the extremity of the intestine. The functions of relation are extremely limited, and most of these molluscs can with difficulty displace themselves by pushing with the foot, or rapidly shutting their shell to eject the water enclosed between the valves, which gives to their body the returning shock; in general they live at the bottom of the waters, or buried in the sand, and some fix themselves to rocks by means of a bundle of horny or silky filaments, which spring from the foot, and is called the byssus.

§ 612. This class is divided, according to the presence or absence of lamellated branchiæ, into two orders. The lamellibranchiata, which comprise oysters, muscles, pearl oysters (Fig. 546), the pectens (clams), the mactræ (Fig. 183), the bucardia (Fig. 547), the solens or knife handles, the teredo, &c. The brachiopoda owe their names to two kinds of fleshy arms, which replace the foot; the terebratulæ (Figs 548 and 549) present this kind of structure.

SUB-DIVISION

OF THE MOLLUSCOÏDES, OR TUNICATA.

§ 613. The animals which we re-unite here are considered by most zoologists as entitled to be arranged, some amongst the molluscs, others amongst the zoophytes; but this opinion seems to depend on the imperfection of the knowledge previously had of the structure of these beings, but now that anatomy and physiology are better known, and have been better studied, it may be seen that they are all formed on the same general plan, and that they establish in some measure the passage between the mollusca properly so called, and the zoophytes. They all have a distinct digestive tube, turned on itself, and open at both extremities, and have a very well developed branchial apparatus (Fig. 551); most of them also present vestiges of a nervous system, but have no ganglionary ring like the mollusca, properly so called; finally, almost all multiply by granulations as well as by ova, and thus form aggregations of individuals more or less completely confounded with each other.

These animals are all aquatic, and are formed on two principal types—the tunicata, properly so called, and the bryozoaria or ciliated polypi.

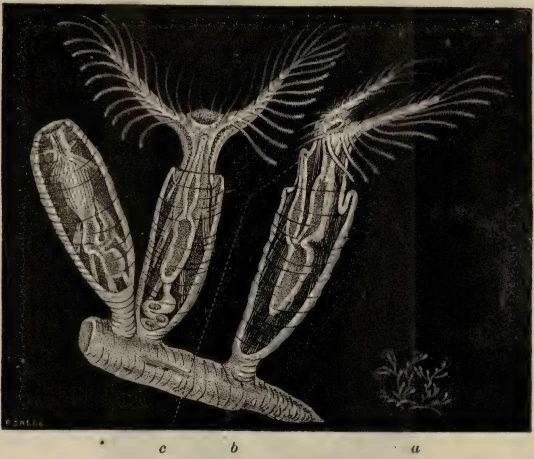

Fig. 550.—Plumatella.*

§ 614. The tunicata, properly so called, are provided with a very large mantle, in the form of a sac (Fig. 551), which constitutes in front of the abdomen or visceral mass a respiratory cavity, enclosing branchiæ, variously arranged. They have a heart, and bloodvessels, in which the nourishing liquid circulates in a very singular manner, for the current changes its direction periodically, so that in the space of some minutes the same canal performs the function of an artery and a vein.

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* *a*, group of the plumatellæ of the natural size; *b*, others magnified, and seen in different positions; *c*, termination of the intestine.

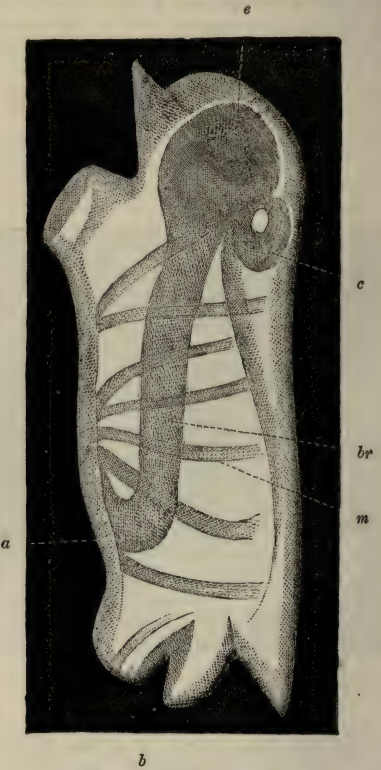

Fig. 551.—Biphore (Biphora.)[*]

In this class are arranged the biphores (Fig. 551), the pyrosoma, and the ascidiæ (Fig. 180), distinguished into simple

[*] *b*, mouth; *a*, anus; *m*, muscular bands surrounding the great pharyngeal or respiratory cavity; *br*, gills; *e*, visceral mass, including the stomach, liver, &c.; *c*, the heart.

and aggregated. These last have often a phytoid appearance.

The history of the biphores presents a very remarkable peculiarity. Successive generations do not resemble each other, but are composed alternately of aggregated and solitary individuals. The first are hermaphrodite, and produce each a younger one, which lives isolated, but which has no reproductive organs, and gives birth, by granulation, to a sort of chain of aggregated individuals. These singular animals are sufficiently common in the Mediterranean.

§ 615. The bryozoaria, which even very lately have been confounded with the more simple polypi, have the mantle less developed, and the gills exposed. The organs consist in a crown of tentacles, which surround the mouth, and which have laterally vibratile cilia (Fig. 550). The anus is near the mantle, and the blood arrives between the viscera and the mouth, as well as in the interior of the tentacles, but is not set in motion by a heart. Finally, the inferior portion of the mantle is generally hardened, so as to form a tube or cellule, sometimes horny, sometimes calcareous, into which the animals may retire altogether. In general these beings, so small as to be almost microscopic, live reunited in masses more or less considerable. Most of them dwell in the sea, but some live in fresh waters. Amongst these last we may mention the alcyonellæ, the plumatella (Fig. 550), common enough in our stagnant waters, and amongst the first, the flustra, the retepora and the vesicularia.

PRIMARY DIVISION.

THE ZOOPHYTES.

§ 616. In this, the fourth and last primary division of the animal kingdom, the organization is much less complete than in most other animals; and the different parts of the economy, instead of being disposed in pairs on each side of a longitudinal plane, are grouped around an axis or central point, so as to give to the whole of the body a radiated or spherical form. The nervous system is either rudimentary or wanting; and there are no special organs of sense, unless it be certain small coloured spots, bearing some analogy to the eyes of the mollusca. In structure, these animals differ widely from each other; and, externally, some more resemble plants than

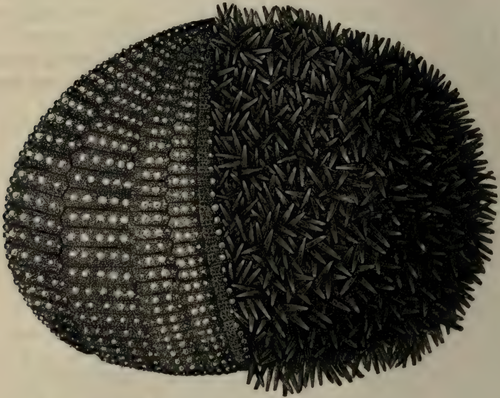

Fig. 552.—The Echinus, or Sea Hedgehog.*

animals. They have been divided into five classes—the *echinodermata*, the *acalepha*, the *polyps*, the *infusoria polygastria*, and the *sponges*.

CLASS OF THE ECHINODERMATA.

§ 617. The echinodermata (Figs. 159 and 186) are radiated animals whose skin is thick, and often supported by a solid skeleton (Fig. 552), with a very complex internal structure. They are formed to creep along the bottom of the waters, and are in general provided with a number of small retractile tentacula, which pass through pores in the integuments, and act by their extremities like suckers. In most zoophytes, the sea urchin and holothuria for example, the digestive cavity has the form of a tube, open at its two extremities; and in others (the sea stars) it consists only of a sac, furnished all around with a number of appendages, more or less branched, with a single aperture communicating externally. The echinodermata have a circulatory apparatus sufficiently developed; and of all the zoophytes are those whose organization is most complex and most perfect. They live in the sea, and when young undergo some remarkable metamorphoses. The echinodermata form three principal groups—the holothuria (Fig. 554), the echinus (Fig. 552), and the asterias or sea star (Fig. 159). Some species of this last family attach themselves by a sort of stalk. Such are, or rather were, the encrinidæ

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* On the left side the spines have been removed to show the shell.

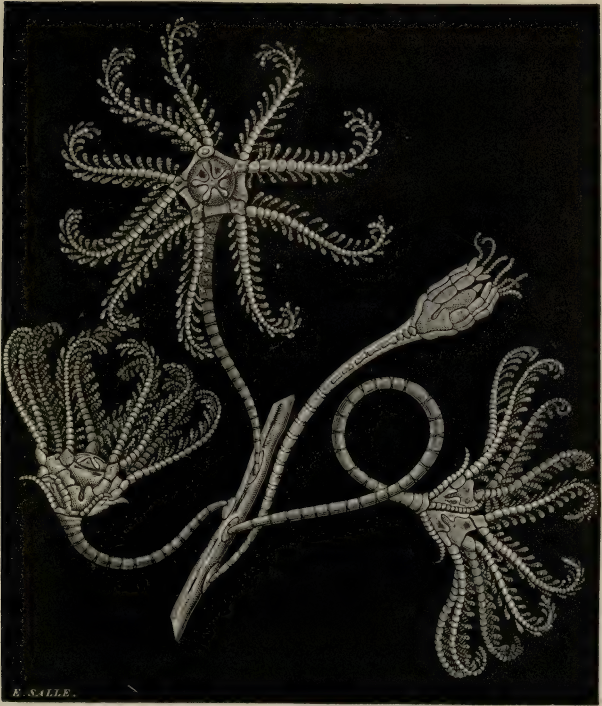

Fig. 553.—Encrinus; Sea Lily.

(Fig. 553), now rarely met with, but which once existed in great numbers in the seas of various geological epochs. The holothuria are remarkable for the disposition of their respiratory apparatus, composed of membranous tubes ramified like a tree, and receiving water into the interior through the intermedium of a cloaca or anus.

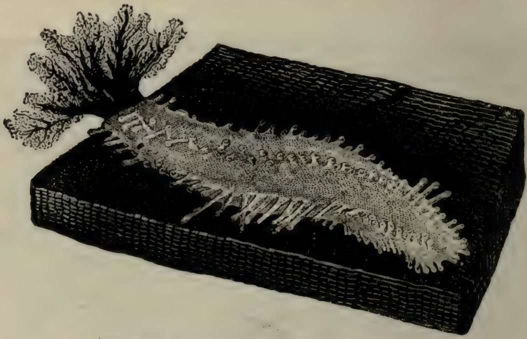

Fig. 554.—Holothuria; Sea Cucumber,

CLASS OF THE ACALEPHÆ.

§ 618. The acalephæ are soft animals, of a gelatinous consistence, always floating in the sea, and formed essentially for swimming. Their organization is very simple; the skin is not distinct from the subjacent parts, and their internal organs are reduced to a cavity or stomach, communicating with the exterior by a single opening, and giving rise to canals extending into the different parts of the body, and there ramifying, so as to give a resemblance to a vascular system.

The family of this class which is best known is that of the medusæ, amongst which are the rhizostomes (rhizostomatidæ), which abound on the coast, and which are remarkable for the singular disposition of the digestive apparatus, the stomach communicating externally by a great number of small canals, terminated by pores at the free extremity of the tentacles. In this class are included the beroes (of the class ciliograda) which resemble small balloons; the cestidæ, which have the form of a long gelatinous ribbon; and the physophoridæ, which have the appearance of a garland of flowers and fruits.*

The medusæ produce eggs like most animated beings, but the young which spring from these in no shape resemble the mother; they are small ovoid bodies, having their surface provided with vibratile cilia, and which soon are fixed, and as they become developed form zoophytes, already known to naturalists by the name of hydroid polypi (sertularidæ, for example); these multiply by granulations, so as to constitute colonies of aggregated animals; and the different individuals of the new generation thus produced become free as they are

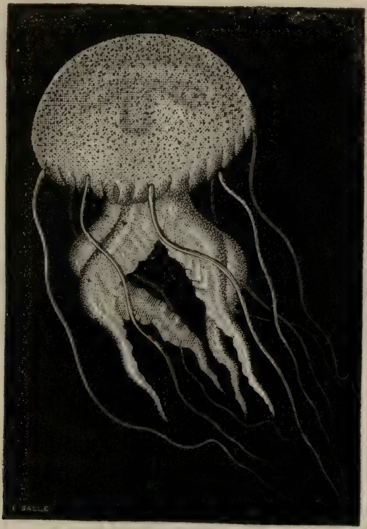

Fig. 555.—Sea Blubber (Medusa Pelagica);
Jelly Fish.

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* In this family, including the physalidæ, the body is floated by air cells, and locomotion performed by parts exposed to the wind.—R. K.

developed, and metamorphosed into medusæ. This succession of individuals of two kinds, which alternately succeed each other and present the same forms only at the second generation, has been called *metagenesis,* or alternating generation.

CLASS OF THE CORALS, OR POLYPI PROPERLY SO CALLED.

§ 619. Some confound under the name of polypi the bryozoaria, of which we have already spoken in treating of the molluscoïds (§ 615), and the corals, or polyps properly so called, which have a structure entirely different and much less complete. These are animals with a cylindrical body, soft, and pierced at one extremity by a central mouth, surrounded with tentacles, and without vibratile cilia (as Fig. 556).

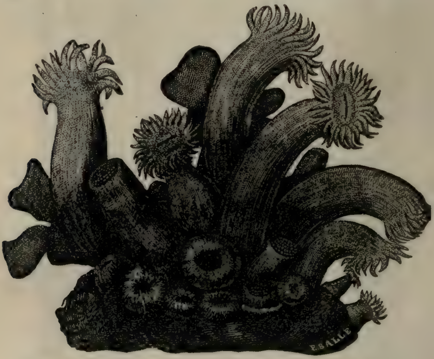

Fig. 556.—Polyp of the genus Astroides; a Coral.

This orifice holds the place of anus, and leads directly, or by the intermedium of a membranous tube, into a large cavity occupying all the body, extending superiorly into the tentacles, and lodging the ovaria suspended to its walls. The inferior extremity of the polyp is contracted, so as to adhere to foreign bodies, on which the animal is destined to live fixed to them; its skin generally hardens to a large extent, so as to form a horny or calcareous envelope, analogous to the cellules of which we have already spoken in describing the bryozoaria. The polyps properly so called, resemble also the molluscoïds by their mode of multiplication; for most of them not only reproduce by means of eggs, but also by means of granulations, which spring from different parts of the surface of their bodies and never become detached; so that different generations remain engrafted as it were on each other, and form larger or smaller masses, in which all the individuals of the same race are included, and live, up to a certain point, a common life.

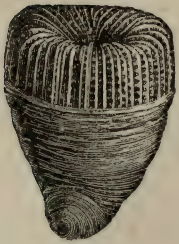

Fig. 557.*

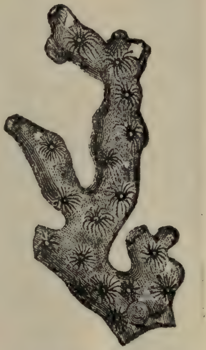

Fig. 558.—Corallines.*

The portion, in some measure ossified, of the tegumentary tunic of these polyps, presents varied forms, and constitutes sometimes tubes, sometimes cellules. For a long period this was considered merely as the dwelling of the polyps which form it, and it is to it that the name of *polypier* has been given. Sometimes each polyp has a distinct *polypier*, but in general it is the common portion of a mass of aggregated polypi which presents the characters peculiar to these bodies, and thus these form aggregated *polypiers*, the volume of which may become very considerable, although each of its constituent parts has dimensions which are very small.

§ 620. It is in this way that polyps with bodies only some lines long raise, in seas adjoining the tropics, reefs and islands. When they are placed in circumstances favourable for their development, certain animals of this class multiply so as to cover chains of rocks or immense submarine banks, and to form, with the rocky masses of their *polypiers* heaped together one above the other, masses of which the extent increases unceasingly by the birth of new individuals, above those already existing. The solid covering of each colony of polyps remains untouched after its frail architects have perished, and serves as a base for the development of other *polypiers*, until the living reef reaches the surface of the waters; for then these animals can no longer live, and the soil formed by their *débris* ceases to rise. But soon the surface of these masses of *polypiers*, exposed to the action of the atmosphere, becomes the seat of a new series of phenomena; grains deposited by the winds, or floated thither by the waves, germinate, and cover the mass with a rich vegetation, until at last these vast charnel-houses of zoophytes almost microscopic, become habitable islands. In the Pacific Ocean a number of reefs and islands have no other origin. In general they seem to have for their base some crater of an extinct volcano, for they have almost always a circular form, and present in the centre a lagoon communicating externally by a single channel: some are known to be more than ten leagues in diameter.

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* Figures not especially referred to in the text.

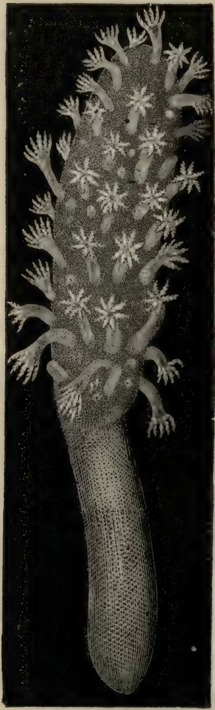

Fig. 559.—Polyps (Veretilli); Star-shaped Polyps, or Sea Fans; Asteroid Polyps.

§ 621. Almost all coral animals inhabit the sea; nevertheless some are found in fresh waters. Those which have the coral case simply fleshy or horny, are spread over all climates; but it is only in the seas of hot climates, or nearly so, that we find an abundance of the coral polyp with a rocky covering or coral case.

Sometimes these aggregated polyps deposit in the interior of the common tissue by which they are united, a horny or calcareous matter, constituting a sort of interior stalk, which branches out like a tree, in proportion as the animated mass sends forth new branches. It is in this way that the coral of commerce is formed (Fig. 189), of which such use is made in the fabrication of ornaments: there is an active fishery for this substance on the coast of Algeria.

The actiniæ belong to this division of the animal kingdom; they are also called sea anemones (Fig. 168); they have a fleshy body, and are found in great numbers on the rocks of our coast; the caryophylli and the astreæ, which, more than all others, assist in the formation of coral reefs (Fig. 190); the coral animal itself (Fig. 189); the veretilli (Fig. 559), which do not adhere to the soil, but are simply buried in the sand by one of the extremities of the common stalk, belong to this division. Most zoologists also class with them the hydra, of which we have already spoken (§ 347).

OF THE CLASS INFUSORIA PROPERLY SO CALLED.*

§ 622. Those animalcules which can only be detected by the microscope, or which, even to a late period, have been confounded with the rotifera (§ 586), but whose structure is very different, are developed in abundance in water containing the remains of organized bodies. Their body, sometimes rounded, sometimes elongated, is often covered with small cilia, and offers in its interior a number, generally very considerable, of small cavities, which seem to perform the functions of stomachs. In some, these little enlargements seem to be grouped around a canal which opens externally by two extremities (Fig. 192); but at other times they seem to be altogether isolated; and persons who have made these little beings the object of a special study, are not agreed as to the existence of a direct communication between this cavity and the exterior. The mode of propagation of the infusoria has been the object of much research, and a great many naturalists think that they may be formed directly by the disintegration of the matters of which leaves, flesh, and other organized bodies are composed; but this spontaneous generation is far from being sufficiently demonstrated, and it is known that, in certain cases at least, they spring from each other. Moreover, their mode of propagation is quite in accordance with the simplicity of their structure: it is by the spontaneous division of their body into two or more fragments, each of which continues to live, and soon becomes a new individual, resembling the first; thus it is that these singular beings in general multiply.

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* Many of the small beings which zoologists place in this group appear rather to belong to the division mollusca than to that of zoophytes; but their natural affinities have not as yet been so clearly established as to enable us to discuss this question here.

Their forms are very varied, and they have been divided into several genera, amongst which we may mention the enchelides (III. Fig. 192), which have an oblong body; the volvoces, which are globular, and continually turn on themselves; and the monads (I. Fig. 192), which resemble small points whirling in the water in which they swim. It is owing to the presence of myriads of a particular species of these small monads, whose bodies are coloured red, that salt stagnant waters or ditches acquire a sanguinolent colour.

CLASS OF THE SPONGIARIA.

§ 623. The sponges (Fig. 191) and the other bodies of an analogous structure, only present the more prominent characters of animality during the early period of their life, and resemble later rather unformed vegetables than ordinary animals. At the time of birth, these singular beings sufficiently resemble certain infusoria; their body is oval, and provided all over with vibratile cilia, by means of which they swim in the waters; in this respect they bear a resemblance to the larvæ of different polyps at the moment when they leave the egg; but soon the young sponges attach themselves to some foreign body, become almost immovable, give no longer any signs of sensibility or of contractility, and as they grow, become completely deformed. The gelatinous substance of their bodies becomes pierced with holes and canals, traversed unceasingly by the waters, and there is developed in their interior a number of horny filaments and spiculæ, sometimes calcareous, sometimes siliceous, which, disposed in cross bundles ,constitute a kind of solid framework. Finally, at certain epochs of the year there are developed in the substance of these shapeless masses, ovoid or spherical corpuscles, which fall into the canals already mentioned, and which, drawn outwards by the current by which the sponge is constantly traversed, constitute species of larvæ or reproductive bodies, endowed with the locomotive faculty mentioned above.

A great number of these sponges, or spongiaria, are known to naturalists; most of them belong to the seas of warm regions, but several live on the rocks of our coast. Those used so abundantly in domestic economy are distinguished by the purely horny nature and by the elasticity of the filaments of which their solid framework is composed; one of the species, the common sponge, is found in great abundance in the Mediterranean; another, called *usual*, belongs to the American seas. These bodies are the object of an important commerce, and to prepare them for the uses to which they are destined it is sufficient to wash them well, so as to detach from their horny skeleton the animal matter with which it is naturally covered.

OF THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

§ 624. To form a general idea of the animal kingdom, it is not sufficient merely to know the principal phenomena by which life manifests itself in animated beings, and to have studied the structure of their bodies and the mechanism of their functions; it is also necessary to take a comprehensive and general view of the manner in which animals are spread over the surface of the globe, and to endeavour to appreciate the influence exercised, or which may be exercised, over them by the various circumstances in the midst of which they are destined to live.

§ 625. When we direct our attention to the manner in which animals are distributed around us on the globe, we are at first struck with the difference of the media in which they live. Some, as every one knows, live always under the waters, and die speedily when they are removed from this liquid; others can live only in air, and perish so soon as they are immerged. Some, in fact, are destined to people the waters, others to live on land; and when we compare, physiologically and anatomically, these aquatic and terrestrial animals, we discover, at least in part, the causes of these differences in their mode of existence.

In studying respiration, we have pointed out a constant relation between the intensity of this function and the vital energy. Animals, we have said, consume in a given time an amount or quantity of oxygen always the more considerable that their movements are more lively and their nutrition more rapid. Now, they can only obtain this oxygen in the fluids with which their bodies are bathed, and in a litre of air (1·760773 pints) there exist 208 cubic centimetres (eighty cubic inches, nearly) of this vivifying principle; whilst in a litre of water there exist dissolved merely about thirteen centimetres (five cubic inches). It is evident, then, that the degree of activity in the respiratory function, indispensable to the exercise of the faculties peculiar to the superior animals, ought to be much more easily attained in air than in water, and that by reason of this difference alone a stay or residence in this latter fluid must be and is interdicted to all the more elevated beings in the animal scale. It is readily comprehended, in fact, that an animal which, in order to live, requires to appropriate to itself at every instant a considerable quantity of oxygen, cannot find it in sufficient proportion when plunged under water, and that then it must perish asphyxiated. But, at first view, it seems less easy to explain the causes by which an aquatic animal cannot continue to live when withdrawn from the water and placed in air, for it is then furnished with a liquid richer in oxygen than was the liquid, the vivifying action of which sufficed for all its wants. There are, however, various circumstances which, to a certain point, explain this phenomenon. Thus we learn by physics (natural philosophy), that a body weighed successively in air and water, is lighter in this latter than in the former, and that to maintain it in equilibrium, a weight equivalent to that which represented its weight in air, less that of the mass of water it has displaced, is then sufficient. From this it results that animals whose tissues are too soft to support themselves in the air, and which collapse to such a degree as to become unfit to perform their functions in the organism, may yet live well in the bosom of the waters where these same tissues, being scarcely denser than the surrounding fluid, have occasion to offer merely a feeble resistance to preserve their forms, and to preserve the different parts of the body from collapsing on themselves. This single consideration suffices to explain why gelatinous animals, such as the infusoria and medusæ, are necessarily confined to the waters; for when we observe one of these delicate beings still plunged in this liquid, we see that all its parts, even the most slender or delicate, support themselves in their normal position, and float with ease in the surrounding medium; but, so soon as we withdraw them from it, their whole body collapses, and presents to the eye merely a shapeless and confused mass. The influence of the density of the surrounding medium on the mechanical play of the instruments of life makes itself also felt on animals whose structure is more perfect, but in which, however, respiration is performed by ramified membranous appendages, like little brushes or bunches of feathers. Thus in the annelides, or even in fishes, the branchiæ or gills are composed of flexible filaments, which support themselves easily in the midst of water, and in this way permit the respirable fluid to reach, and to be renewed at all points of their surface; but in the air these same membranous filaments collapse by the effect of their own weight, fall on each other, and by that alone exclude the oxygen from the greater part of the respiratory apparatus. From this it results that this function is then shackled, and that the animal may die asphyxiated in the air, whilst he found in water that which he required to breathe freely. To be convinced of the importance of these variations in the physical condition of organs placed in air or in water, it is sufficient to recal what takes place in our practical or dissecting-rooms. An anatomist desirous of studying the structure of a delicate part, would attain his object with difficulty, if he made his dissection with the part exposed simply to the air; but by placing under water the object of his study, he is thereby enabled to distinguish much more readily all its parts; for these parts, supported in some measure by the liquid, preserve then their natural relations as if they had a rigid and consistent tissue. Another circumstance which has an equal influence over the possibility of life in air or in water, is the evaporation which always takes place from the surface of the organized bodies when placed in air, but which does not happen in water. A certain degree of desiccation causes all organic tissues to lose their distinguishing physical properties, and we constantly observe that losses by evaporation cause the death of animals when it goes beyond certain limits. It results from this, that beings whose organization is not calculated so as to preserve them from the injurious effects of such an evaporation, can live only in water, and perish promptly in the air. Now the animal economy can only meet this exigency by means of a great complication in its structure. In fact, if the respiration must be active, it becomes necessary that the respiratory surface be then lodged profoundly in some internal cavity where the air can only be renewed in the quantities necessary for the support of life. To secure this renewal, it is essential that the respiratory apparatus be complicated with motor organs proper to secure it; to prevent the desiccation of any portion of the surface of the body, it becomes necessary also that the distribution of the liquids in the various parts of the body be accomplished easily, and that there exist an active circulation, or otherwise that this surface be clothed with a tunic scarcely permeable. This is so true, that even in fishes, in which the circulation is so complete, but takes place slowly, and in which the capillary network is not very close, death takes place rapidly, as a necessary consequence of the desiccation of a part of the body—of the posterior portion, for example—even when this portion alone is exposed to the air, all the rest of the animal remaining plunged under water.

We might also add, that in water, alimentation is possible with instruments of prehension and of motion less perfect than in air, in which the transport of foreign matters required by the animal is more difficult to accomplish. Thus, under all its more essential relations, life is, in some measure, easier to sustain in the bosom of the waters than on the surface of the dry land; it necessitates in the atmosphere physiological instruments more complex and more perfect; therefore the waters are the natural element of the animals placed lower in the scale of the zoological series; and if the productions of the creation have succeeded each other in the same order of the transitory conditions through which each animal passes during the period of its development, we may conclude that it was in the middle of the waters that animated beings appeared first, a result which accords with the observations of geologists and the assertions of Scripture. The physiologist may in this manner give an account of the actual mode of distribution of animals between the two geological elements which divide the surface of the globe, land and water: but these fundamental differences are not the only ones which we observe in the geographical distribution of animated beings. If a naturalist familiar with the fauna of this country, visit distant regions, he sees, in proportion as he advances, the earth peopled with animals new to him, and these species next disappear in their turn to make room for other species equally unknown to him. If, quitting France, he lands in South Africa, he will find but a very small number of animals similar to those he had seen in Europe, and he will observe, especially, the large-eared elephant, the hippopotamus, the double-horned rhinoceros, the giraffe, innumerable flocks of antelopes, the zebra; the Cape buffalo, whose horns cover by their large base all the forehead; the black-maned lion; the chimpanzee, which, of all animals, most resembles man; the cynocephalus, or dog-faced ape; peculiar species of vultures; a number of bright-plumaged birds, strangers to Europe; insects equally different from those of the north, the fatal termites, for example, which live in numerous societies, and build of the soil habitations of considerable elevation and most singular construction.

§ 626. If our zoologist quits the Cape of Good Hope and penetrates into the large island of Madagascar, he will there find a still different fauna. There he will no longer observe the large quadrupeds he found in Africa, and the family of the apes will be replaced by other mammals, equally well formed to climb trees, but more resembling the carnivora, and called by naturalists the *Makis:* he will meet with the *Aye-aye*, an animal of the most singular nature, which seems to be the object of a sort of veneration on the part of the inhabitants, and which is essentially a true Quadrumanous animal; the tenrecs, small insectivorous mammals, which have the back protected with spines or quills, like our hedgehogs, but which yet do not roll themselves up into a ball; the cleft-nosed chameleon, and several curious reptiles not found elsewhere, as well as insects no less characteristic of this region.

§ 627. Still travelling onwards and arriving in India, our traveller will find an elephant distinct from that of Africa; oxen, bears, rhinoceroses, antelopes; stags, equally different from those of Europe and of Africa; the oran-outan, and a number of other apes peculiar to these countries; the royal tiger, the argus, the peacock, the pheasant, and an almost innumerable multitude of birds, reptiles, and insects unknown elsewhere.

§ 628. Should he afterwards visit New Holland, still everything will be new to him, and the aspect of this fauna will appear to him still more strange than that of the various zoological populations he had already passed in review. He will then no longer find animals analogous to our oxen, horses, bears, and to a great number of our large carnivora: the quadrupeds of great stature will be found totally wanting, and he will discover the kangaroo, the flying phalanger, and the ornithorhynchus.

§ 629. Finally, if our traveller, in order to return to his native country, should traverse the vast continent of America; he will discover there a fauna analogous to that of the Old World, but composed almost entirely of different species: he will there find apes with prehensile tails; large carnivora, sufficiently resembling our lions and tigers, bisons, lamas, tatous; finally, birds, reptiles, and insects, equally remarkable, and equally new to him.

§ 630. Differences no less striking in the species of animals peculiar to different regions of the globe, are observable, when, instead of confining our observation to the inhabitants of the land, we examine the myriads of living beings which live in the midst of the waters. In passing from the coast of Europe into the Indian Ocean, and from this last into the seas of America, we meet with fishes, molluscs, crustacea, and zoophytes peculiar to each of these parts of the sea. This localization of species, whether aquatic or terrestrial, is so well marked that a naturalist a little experienced cannot mistake at the very first sight the origin of zoological collections made in one or other of the great geographical divisions of the globe which may be submitted to his examination. The fauna of each of these divisions presents a peculiar aspect, and may be easily characterized by the presence of certain species, more or less remarkable.

§ 631. Naturalists have imagined several hypotheses to explain this mode of distribution of animals on the surface of the globe; but in the actual state of science it is impossible to give a satisfactory explanation, unless we admit that from the beginning of the actual geological period the various species have been distributed in the different regions, and that by degrees they have afterwards spread to a distance, so as to occupy a more or less considerable portion of the surface of the globe. In the actual condition of the globe, it is impossible for us to discover all the zoological focuses; for one may imagine the possibility of exchange so multiplied between two regions, the faunæ of which were primitively distinct, that they can only now offer at the present moment species common to both, and thus nothing can reveal to the eyes of the naturalist their original separation: but when a country is found to be peopled with a considerable number of species not to be found elsewhere, even where the local circumstances most resemble, we shall be authorized to think that such a portion of the globe has always been a distinct zoological region.

[Buffon was the original author of the great practical thought or theory included in the preceding paragraph; he it was who discovered and first spoke of "*centres* of creation." It has been ascribed by some English writers to a former student of mine, Mr. E. Forbes, who assuredly never claimed it in his own name. But he ought to have disavowed it when ascribed to him by others, whose motives for doing so may very readily be guessed at.

M. Schlegel, in his admirable work on the *Physiognomy of Serpents*, has written a memoir on this subject, which I should with much pleasure have added to this work, were it not that the subject in reality belongs to the philosophy of zoology, a matter which the author does not profess to treat of in this valuable elementary work; from it, however, I give the following passage, reminding the reader that the work was written at least twenty years ago.

"By cultivation the earth loses its primitive aspect. Serpents are peculiar in many respects, and their natural history is eminently calculated to elucidate the great questions of foci or centres of creation, and the *immutability* of *species*." (p. 197.) The ophidians of Japan are distinct from all others; so also are those of Madagascar." SCHLEGEL.—R. K.]

What the naturalist ought to inquire into is, not how it happens that the various points of the globe are inhabited at the present day by different species, but rather how these animals have been able to spread themselves to a distance over the surface of the globe, and how nature has set to this diffusion variable limits, according to the species. This last question especially presents itself to the mind, when we observe how unequal is the extent of the domain occupied by different animals. The oran-outan, for example, confined to the Island of Borneo and the neighbouring territories; the musk-ox, limited to the most northern parts of America, and the llama, to the elevated regions of Peru and of Chlli;

whilst the wild duck is found everywhere, from Lapland to the Cape of Good Hope, and from the United States of America to China and Japan.

The circumstances which favour the dissemination of species are of two kinds. The first is connected or dependent on the nature of the animal itself; the second, with causes foreign to it. In the number of the first, the development of the locomotive power holds an important place. All things being equal, the species which live fixed to the soil, or which possess but imperfect instruments for locomotion, occupy but a restricted portion of the surface of the globe, compared with species whose movements of translation are rapid and energetic. Thus, amongst terrestrial animals, birds offer us most examples of cosmopolitan species; and amongst the aquatic animals, cetacea and fishes. Reptiles, on the contrary, are generally cantoned on narrow limits; and the same may be said of most of the molluscs and of the crustacea. The instinct which leads certain animals periodically to change their climate, contributes also to cause the dissemination of species; and this instinct, as we have already seen, exists in a great number of these beings. Amongst the circumstances foreign to the animal, and in some measure accidental, concurring to bring about the same result, the influence of man may be placed foremost; and to give of this an exact idea, it will be sufficient to mention a few species. The horse originally belonged to the steppes of Central Asia; and at the epoch of the discovery of America, there did not exist in the New World an individual of the species. The Spaniards transported the horse with them at an epoch which does not ascend beyond three ages; and in our day, not only the inhabitants of this vast continent, from Hudson's Bay to Terra del Fuego, possess horses in abundance, but these animals have even recovered their wild condition, and are found in troops almost innumerable. It is the same with our domestic ox. Carried from the Old to the New World, they have increased to such an extent, that in some parts of South America they are hunted solely with a view to obtain the hides for the manufacture of leather. The dog also has been everywhere the companion of man; and we may add to the number of animals become cosmopolitan in our time, the rat, which seems originally to have been American, which entered Europe in the Middle Ages, and may now be found even in the isles of Oceanica.

In some instances animals have been able to burst natural barriers seemingly insurmountable, and to spread themselves over a more or less considerable portion of the surface of the globe by means of circumstances which at first sight seem extremely unimportant,—such as the movement of a fragment of ice, or of a morsel of wood swept along by currents to distances often very considerable: thus nothing is more common than to meet at sea, at a distance of hundreds of leagues from all land, fuci floating on the surface of the water, supporting small crustacea incapable by themselves of removing by swimming to any great distance from the coasts where they were produced. The great maritime current which, leaving the Gulf of Mexico, coasts along North America as high as Newfoundland, then directs itself towards Iceland and Ireland, and redescends towards the Azores, often carries with it, even to the coasts of Europe, trunks of trees, which the Mississippi has torn away from parts the most remote of the New World, and carried to the sea. Now these timbers are often bored by the larvæ of insects, and may give attachment to the eggs of mollusca, insects, &c. Finally, even birds contribute to the dispersion of living beings over the surface of the globe, and that in a most singular manner; these animals often do not digest the eggs they swallow, and, discharging them at considerable distances from the place where they had found them, transport to a distance the germs of a race unknown to that time in the countries where they have been deposited. Notwithstanding these means of transport, and of other circumstances equally calculated to favour the dissemination of species, there are really very few animals cosmopolitan, and most of these beings are cantoned in regions sufficiently limited. Moreover, we comprehend why it should be so in studying the circumstances which may oppose their progress. But this study is far from furnishing us with a sufficient explanation of the limited circumscription of a species, and it is often impossible for us to divine why certain animals remain confined to a locality when there seems to be nothing opposed to their propagation in neighbouring districts.

§ 632. However this may be, the obstacles to the geographical dissemination of species are sometimes altogether mechanical, at other times physiological; and amongst the first we may mention seas and high chains of mountains. For terrestrial animals, in fact, seas of a certain extent form in general an insurmountable barrier; and we see that, all things being equal in other respects, the mixture of two distinct faunæ is always the more intimate that the regions to which they belong are more geographically approximated, or are placed in communication by intermediate lands. Thus the Atlantic Ocean prevents the species proper to Tropical America from spreading into Africa, Europe, and Asia; and the fauna of the New World is completely distinct from that of the Old, unless it be in the more elevated latitudes towards the northern pole; but there the lands approach: America is only separated from Asia by the straits of Behring, and holds relations with the north of Europe through Greenland and Iceland; thus zoological exchanges could take place much more easily, and it is there, in fact, that we find the species common to the two worlds,—such as the white bear, the reindeer, the beaver, the ermine, the pelerine falcon, the white-headed eagle, &c. Lofty chains of mountains constitute also natural barriers which often arrest the dispersion of species, and prevent the fusion of faunæ peculiar to neighbouring zoological regions. Thus the two slopes of the Cordilleras of the Andes are inhabited by species generally distinct; and the insects of Brazil, for example, are almost all distinct from those we meet with in Peru or in New Granada. The dispersion of marine animals living near the coast is shackled in the same way by the geographical configuration of the globe; but here it is sometimes a long contiguity of land, sometimes a vast extent of the deep sea, which opposes itself to the dissemination of species. Thus most of the animals of the Mediterranean are also found in the European portion of the Atlantic, but have not been able to reach the Indian seas, from which the Mediterranean is separated by the isthmus of Suez; nor to traverse the Atlantic Ocean, to spread themselves on the coasts of the New World.

§ 633. The physiological circumstances which tend to limit the different faunæ are more numerous; but that which presents itself in the first place is unquestionably the unequal temperature of the different regions of the globe. There are species which can support equally well an intense cold and tropical heat; man and the dog, for example; but there are others which in this respect are less favoured by nature, and which do not prosper, or even cannot exist, but under the influence of a fixed temperature. Thus the apes which crowd the tropical regions almost always die of phthisis (pulmonary consumption) when they are exposed to the cold and humidity of our climate; whilst the reindeer, formed to support the rigours of a long and rude Lapland winter, suffers from heat at St. Petersburg, and in general sinks quickly under the influence of a temperate climate. From this it results that, in a great number of cases, differences in climate alone are found to be sufficient to arrest the march of species from high latitudes towards the equator, or from equatorial regions towards the poles. The influence of temperature on the animal economy explains to us also why certain species remain cantoned in a chain of mountains without being able to spread abroad into analogous localities. We know, in fact, that the temperature decreases by reason of the elevation of the soil, and that in consequence animals which live at considerable elevations could not descend into the low plains to reach other mountains, without traversing countries where the temperature is much superior to that of their ordinary habitation. The genus llama, for example, abounds in the grassy countries of Peru and of Chile, situated at an elevation of four or five thousand metres (from four to five thousand yards) above the level of the sea, and extending to the south as far as the extremity of Patagonia; but they are to be found neither in Brazil nor Mexico, because they could not arrive there without descending into regions too hot for their constitution.

The nature of the vegetation and of the pre-existing fauna in a region of the globe equally influences its appropriation by exotic species. Thus the dispersion of the silkworm is limited by the disappearance of the mulberry above a certain degree of latitude; the cochineal cannot spread itself beyond a region where grows the cactus; and the large carnivora, unless they live on fish, cannot exist in the polar regions, where the vegetable productions are too scant to support a considerable number of herbivorous quadrupeds.

§ 634. It were easy for us to multiply examples of these necessary relations between the existence of an animal species in a given locality, and the existence of certain climatic, phytological, or zoological conditions; but we want space for such details, and the considerations we have just given appear to us sufficient to give an idea of the manner by which nature has accomplished the repartition of animal species over different points of the surface of the globe; and to attain the end we proposed in touching on this subject, it only remains for us to take a view (*coup d'œil*) of the results brought about by the different circumstances of which we have just spoken, that is to say, of the actual condition of the geographic distribution of animated beings. When we compare the various regions of the globe with each other in the relation of their zoological population, one is struck at first with the extreme inequality observable in the number of species. In a certain country, for example, we meet with an extreme diversity in the forms and the structure of the animals composing its fauna, whilst elsewhere there reigns in this respect a great uniformity; and it is easy to observe a certain relation between the different degrees of zoological richness and the elevation, more or less considerable, of the temperature. In fact, the number of species, as well marine as terrestrial, augments in general in proportion as we descend from the poles towards the equator. The more remote polar regions offer to the traveller only a few insects, and in its icy seas the fishes and the mollusca themselves are but little varied; in temperate climates the fauna becomes more numerous in species; but it is in the tropical regions that nature shows herself most prodigal in this respect, and the zoologist cannot see without astonishment the endless diversity of animals which are accumulated there.

It is remarkable also that there exists a singular coincidence between the elevation of the temperature in different zoological regions, and the degree of organic perfection of the animals inhabiting them. It is in the hottest climates that we find the animals which most approach man, and those which in each great zoological division possess the organization the most complex, and the faculties most developed; whilst in the polar regions we meet only with beings occupying a rank but little elevated in the zoological series. The apes, for example, are limited to the hottest parts of the two continents; it is the same with the parrots amongst birds; the crocodiles, the turtles, and tortoises amongst reptiles, and land-crabs amongst the crustacea,—all animals the most perfect in their respective classes.

It is also in hot countries that we find the terrestrial the most remarkable for the beauty of their colours, the size of their bodies, and the singularity of their forms.

Finally, there seems to exist a certain relation between the climate and the tendency of nature to produce such or such an animal form. Thus we observe a great resemblance between most of the animals inhabiting the Boreal and Austral regions; the faunæ of the temperate regions of Europe, Asia, and North America offer a great analogy in their general aspect; and in the tropical countries of the two worlds we see predominating similar forms. It is not that we find identical species in regions distinct and nearly isothermal, but species more or less neighbouring, and which seem to be the representatives of one and the same type. Thus, the apes of India and of Central Africa are represented in tropical America by other apes, easily distinguished from the first; to the lion, the tiger, and the panther of the Old Continent, correspond in the New World the puma, the jaguar, and the ocelot. The mountains of Europe, of Asia, and of Northern America nourish bears of different species, but still presenting but slight differences. Seals abound especially in the neighbourhood of the two polar circles; and if we wish to look for proofs of this tendency, not in the more elevated classes of the animal kingdom, but amongst the inferior beings, we shall find them no less evident; the craw-fishes and lobsters, &c., for example, appear to be confined to the temperate regions of the globe, and are found spread abroad throughout the greatest part of Europe, by the species so common in our rivulets, in the south of Russia by a different species, in Northern America by two other species equally distinct from the preceding, in Chile by a fourth species, to the south of New Holland by a fifth, in Madagascar by a sixth, and at the Cape of Good Hope by a seventh.

The comparison of the faunæ peculiar to the different zoological regions of the globe conducts to other results, of which it is more difficult to give an explanation. Thus, when we examine successively the whole of the species inhabiting Asia, Africa, and America, there may be observed in the fauna of the New World a character of inferiority which did not escape the celebrated Buffon. In fact, there do not exist in the New World mammals so large as in the old continents; we find indeed in Northern America a considerable number of apes, but amongst these animals there are none equal to the ourang and chimpanzee; and it is rather the rodents and the edentata which abound the most, that is to say, of all ordinary mammals the least intelligent. Finally, it is in America that we meet with the sarigues (opossums), animals which belong to an inferior type of ordinary mammals, and which have no representatives in Europe, Asia, or Africa. If we pass afterwards from the New World to Australia, a still newer region, we find a fauna the inferiority of which is still more evident, for the class of mammals is there scarcely represented by the marsupialia and the monotremes.

With regard to the delimitation of the different zoological regions which divide the globe, and to the composition of the fauna peculiar to each of them, we cannot treat of it here without passing beyond the limits prescribed by this course of instruction, and we the less regret this necessity seeing that in the actual state of the science these questions are far from being solved.

We shall even close here our zoological studies, for the object we had proposed to ourselves was not the particular description of each animal, nor the enumeration of the characters by which they might be known or grouped methodically; we only wish to give in this course ideas on the nature and properties of these beings, to sketch rapidly the principal traits of their history, and to furnish to our young readers the general knowledge the most useful to all, and indispensable to those who wish to study more deeply this branch of the sciences of observation.

[The following tables of the Classification of the Animal Kingdom are appended for the convenience of the student. The first is that used in my Lectures at the London Institution in 1863; the second is founded on the classification of Owen.—C. C. B.]

1. CLASSIFICATION OF THE ANIMAL KINGDOM.

Sub-kingdom VERTEBRATA.

Hæmatotherma	Mammalia. Aves.
Hæmatocrya	Reptilia. Pisces.

Sub-kingdom MOLLUSCA.

Cephalopoda.
Gasteropoda.
Pteropoda.
Brachiopoda.
Conchifera.
Tunicata.

Sub-kingdom ARTICULATA.

Insecta.
Arachnida.
Crustacea.
Cirripedia.
Annelida.
Entozoa.

Sub-kingdom RADIATA.

Bryozoa.

Acalephæ.
Anthozoa.
Hydrozoa.

Echinodermata.

Kingdom ACRITA, or PROTOZOA.

Infusoria.
Foraminifera.
Amorphozoa.

2. TABLE OF THE ORDERS OF VERTEBRATA.

Class MAMMALIA.

Sub-class ARCHENCEPHALA.	EXAMPLE.
Order 1. *Bimana*	Man.
Sub-class GYRENCEPHALA.	
Order 2. *Quadrumana*	Ape.
,, 3. *Carnivora*	Lion.
,, 4. *Artiodactyla*	Ox, Hog.
,, 5. *Perissodactyla*	Tapir.
,, 6. *Proboscidea*	Elephant.
,, 7. *Toxodontia*	Toxodon(fossil).
,, 8. *Sirenia*	Dugong.
,, 9. *Cetacea*	Whale.
Sub-class LISSENCEPHALA.	
Order 10. *Bruta*	Armadillo.
,, 11. *Cheiroptera*	Bat.
,, 12. *Insectivora*	Mole.
,, 13. *Rodentia*	Rat.
Sub-class LYENCEPHALA.	
Order 14. *Marsupialia*	Opossum.
,, 15. *Monotremata*	Platypus.

Class BIRDS.

Order 1. *Raptores*	Eagle.
,, 2. *Scansores*	Parrot.
,, 3. *Volitores*	Swift.
,, 4. *Insessores*	Sparrow.
,, 5. *Rasores*	Turkey.
,, 6. *Cursores*	Ostrich.
,, 7. *Grallatores*	Stork.
,, 8. *Natatores*	Duck.

Class HÆMATOCRYA.

Sub-class Reptiles.

Order 1.	*Batrachia*	Frog.
,, 2.	*Chelonia*	Tortoise.
,, 3.	*Ophidia*	Snake.
,, 4.	*Lacertilia*	Lizard.
,, 5.	*Crocodilia.*	Crocodile.
,, 6.	*Dinosauria*	Fossil forms.
,, 7.	*Pterosauria*	
,, 8.	*Anomodontia*	
,, 9.	*Sauropterygia*	
,, 10.	*Ichthyopterygia*	
,, 11.	*Thecodontia*	
,, 12.	*Labyrinthodontia*	
,, 13.	*Ganocephala*	

Sub-class Fishes.

Order 14.	*Plagiostomi*	Shark.
,, 15.	*Holocephali*	Chimæra.
,, 16.	*Protopteri*	Mudfish.
,, 17.	*Placoganoidei*	Coccosteus(fossil).
,, 18.	*Ganoidei*	Bony pike.
,, 19.	*Lophobranchii*	Pipe fish.
,, 20.	*Plectognathi*	File fish.
,, 21.	*Acanthopteri*	Perch.
,, 22.	*Anacanthini*	Cod.
,, 23.	*Pharyngognathi*	Parrot fish.
,, 24.	*Malacopteri*	Herring.
,, 25.	*Dermopteri*	Lamprey.

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